The Mesolithic/Neolithic Transition in the Southern Region of Ireland:

A Bayesian Approach to the Integration of the Palaeoenvironmental and Archaeological Records.

Volume 1 of 1

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Abstract

This interdisciplinary study has assessed the evidence the Mesolithic/Neolithic transition (*c.*4500 – 3750 cal BC) in southern Ireland, examining the timing, extent and nature of woodland disturbance, agricultural activity and settlement during the period. This study represents the first explicit use of the Bayesian approach to address these issues and served to refine and integrate the two principal proxies available for investigating human activity during the Mesolithic/Neolithic transition. The integration of the palaeoenvironmental and archaeological records, within a Bayesian framework has allowed for the formulation of new hypotheses concerning patterns of vegetation change and the timing and intensity of human activity during the period.

This thesis has demonstrated that the Early Neolithic archaeological record indicates that these practices began quite rapidly, with occupation sites associated with Early Neolithic material appearing from *c.*3750 cal BC. However, the early cattle bones from Ferriter's Cove and Kilgreany Cave remain somewhat of an enigma in the context of the Early Neolithic in the region.

This thesis redresses the geographical imbalance which had previously existed within palaeoenvironmental studies of the Late Mesolithic and Early Neolithic period in Ireland. The two new palynological records have provided robust, well-dated profiles which have been highly informative of the changing mid-Holocene landscape in southern Ireland.

A distinct *Landnam* phase is exhibited at Lough Cullin which involved sustained woodland clearance and farming activity over several centuries, however, this occurred prior to the start of occupation at the Early Neolithic archaeological sites of the region. The statistical correlation between the date for the cattle bone from Kilgreany Cave and this *Landnam* phase may indicate the presence of domesticates in the region at the time when the most intense phase of woodland clearance was occurring which would have serious implications for our understanding on the timing and process of Neolithisation in Ireland.

The mid-Holocene 'Elm Decline', often viewed as a chronological proxy for the start of the Neolithic, was demonstrated to be asynchronous across all sites investigated, and no degree of spatial cohesion was evidenced for this 'event'. A correlation between anthropogenic activity and the onset of the 'Elm Decline' can be suggested at several

sites, although this need not necessarily be ‘Neolithic’ activity. However, this was not in general agreement across all sites, indicating that the ‘Elm Decline’ across the island was a complex, multifactor, site-specific process.

To conclude, the results of this thesis have produced a new body of critically assessed palaeoenvironmental data for the period. This study has contributed new perspectives on the timing and nature of human-environment interactions during this period of seismic cultural change. It has pioneered the use of the Bayesian approach to the integration and interpretation of complementary proxy records for human activity, highlighted the need for more considerations as to the chronological approaches taken by archaeological and palaeoenvironmental researchers.

Declaration

I hereby declare that the work presented in this thesis is entirely my own, except where otherwise acknowledged in the text, and that this thesis has not been presented for a degree at University College Cork or any other University.

Signed:

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Kevin Kearney

Glossary

Abbreviations/Acronyms used:

AP Arboreal pollen

BP Radiocarbon years before present

cal. BC where 'cal' indicates 'calibrated years' before Christ

cal. BP where 'cal' indicates 'calibrated years' before present

DCA Detrended Correspondence Analyses

ITM Irish Transverse Mercator

LOI Loss on Ignition

MCMC Markov Chain Monte Carlo (Bayesian/OxCal statstics)

NAP Non-arboreal pollen

NGR National Grid Reference

NRA National Roads Authority

PAZ Pollen Assemblage Zone

PDE *Posterior density estimate*

Taxonomy All taxa are presented in Latin and italicized in tables and graphs. Plant species/genus are presented in Latin with English common names in parenthesis when first mentioned in the text. The English common names are then used in general text discussions.

TII Transport Infrastructure Ireland (formerly NRA)

TLP Total land pollen

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Chapter 1 - Introduction

1.1. Introduction

The origins and the spread of agriculture, and its associated societal impacts is a major focus of archaeological research not only in Ireland but internationally. The 'seismic' cultural shift from forager to farmer represents one of the fundamental watersheds in human history, with the development of sedentary societies and the creation of a food-producing economy. This transition has been widely explored across much of Europe, with numerous studies detailing the expansion of agriculture from southern and central Europe to the more peripheral northern and western limits (e.g. Innes and Blackford 2003; Rowley-Conwy 2011; Sjögren *et al.* 2014). While Ireland has often been conspicuously overlooked in such studies, increased archaeological and palaeoecological research over the past few decades has cast new light into the earliest Neolithic in Ireland (e.g. Molloy and O'Connell 1991; Cooney 2000; O'Connell and Molloy 2001; Cooney *et al.* 2011; Smyth 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016).

With the majority of this palaeoenvironmental research having been undertaken in the northern and western regions of Ireland (e.g. Smith 1970; O'Connell 1986; 1987; 1990; O'Connell and Molloy 2001; Ghilardi 2012; Stolze 2012b; Chique *et al.* 2017), questions remain over the nature of the earliest Neolithic in the southern counties of Ireland, where comparatively less consideration has been given. The assumption that the region remained largely uninhabited until the final stages of the Neolithic (Lynch 1981; Woodman *et al.* 1999) has recently been challenged by new discoveries of Early Neolithic sites. The recent excavation of settlements with house structures on several road schemes (e.g. Danaher 2003; O' Donoghue 2006), housing developments and gas pipeline construction (e.g. Gowen 1988; Kiely 1999; Cleary 2015a) adds to the small number of portal and passage tombs known in the region.

This interdisciplinary study has explored the forager to farmer interface (*c.*4500 – 3750 cal BC) in the southern region of Ireland, through the explicate use of the Bayesian approach to integrate the palaeoenvironmental and archaeological records. This study represents the first of its kind to be undertaken in relation to the Mesolithic/Neolithic transition in Ireland. This research has built on recent Bayesian analysis of the radiocarbon record, (McSparron 2008; Cooney *et al.* 2011; McLaughlin *et al.* 2016), by collating, analysing and synthesising published and unpublished excavated site reports from the region and undertaking Bayesian chronological modelling of relevant data. This was complemented by qualitative and quantitative palynological analysis from sites close to known Early Neolithic monuments, to obtain palynological records at temporal and spatial scales relevant to archaeological understanding.

Precise chronological control was essential in the integration of these records and recent developments using Bayesian approaches offere the potential for more sophisticated modelling of palynological 'events' (Bronk Ramsey 2008). The application of Bayesian modelling (Bronk Ramsey 2009a; Ramsey *et al.* 2013) has allowed for more a robust chronology of clearance and cultivation phases to be established, which was necessary for the integration of the palaeoenvironmental and archaeological datasets. The inclusion of Bayesian modelling and the integration of palaeoenvironmental and archaeological chronologies has allowed for the formulation of new hypotheses concerning patterns of environmental change and the timing and intensity of human activity during the Early Neolithic period.

1.2. Aims and objectives of this thesis

The main focus of this research has been to enhance the understanding of the process of Neolithisation in southern Ireland by exploring the nature of human-environment interactions during the transition from the Late Mesolithic to the Early Neolithic (*c.*4500 – 3750 cal BC). As outlined above, despite the considerable advances in knowledge, made by both archaeological and palaeoenvironmental research into this subject over the past two decades, the nature of the earliest Neolithic in the southern region is still poorly defined. This study, therefore, sought to redress this imbalance in our understanding of the period through the systematic integration of archaeological and palaeoenvironmental, primarily chronological, datasets.

To successfully address this issue this study incorporated three principal aims and associated objectives:

1. The first aim of this research was to establish a comprehensive and robust chronology of the Early Neolithic archaeological record of the region. To successfully address this aim, the following objectives were established:

a) A comprehensive database of known and likely Early Neolithic archaeological sites was compiled from the available published and unpublished excavation reports.
b) The radiocarbon dates from all suitable Early Neolithic contexts were incorporated within a Bayesian framework to provide a refined chronology for the start of the Neolithic in the region.

2. The second aim of this research was to contextualise the archaeology of the Early Neolithic within its contemporary prehistoric landscape. To successfully address this aim, the following objectives were established:
    a) The database of archaeological sites undertaken as part of Objective 1a was assessed within a landscape context to identify regions of archaeological significance suitable for further palaeoenvironmental analysis.
    b) Suitable sites for palaeoecological assessment were identified based on a correlation of the distribution of archaeological evidence and availability of sampling sites. Small basins in close proximity to archaeological contexts and covering sufficient temporal resolution were the optimum choice.
    c) All potential sampling sites established under Objective 2b were assessed to identify two locations suitable for palaeoenvironmental analysis.
    d) Palaeoenvironmental analysis was undertaken of the suitable sampling sites identified in Objective 2c.
    e) A robust chronology for resulting palaeoecological sequences was established using AMS dating, especially across the Mesolithic/Neolithic transition. The results of which were further refined by the application of Bayesian modelling techniques.
3. The third aim of this research was to integrate the results of Aims 1 and 2, to test hypotheses regarding the timing, extent and ecological impacts of the adoption of Neolithic practices in the region. To successfully address this aim, the following objectives were established:
    a) The chronology of palynological 'events' often associated with the transition to the Neolithic identified in Objective 2d was statistically compared with the results of Objective 1b within a Bayesian framework to assess the robustness of this correlation.

b) The nature of the mid-Holocene ‘Elm Decline’ was assessed within temporal and spatial parameters to assess the supposed synchroneity of this ‘event’, and to determine any spatial patterns and whether a connection with Neolithic anthropogenic activity can be robustly established.
c) The implications of the study on the understanding of the process of Neolithisation in Ireland were assessed.
d) Furture research questions and the implications for broader archaeological understanding were identified.

1.3. Background to this research

1.3.1. A history of archaeologically related palynological research in Ireland.

The beginnings of archaeo-palynological studies in Ireland is represented by the investigations of Gunnar Erdtman at fifteen sites in the 1920’s, which established the earliest outline of post-glacial vegetation developments for the island (Erdtman 1928). The Committee for Quaternary Research, established in 1933, funded the examination of pollen profiles for a further thirty archaeological sites, applying the methodologies of the natural sciences to archaeology. Knud Jessen’s (1949) publications, fifteen years later would bring Irish pollen analytical studies to the forefront in Europe.

G.F. Mitchell, who trained under Jessen, would become the driving force behind palynological studies in Ireland for much of the early and mid-twentieth century. Mitchell’s research established a pollen sequence for more than one hundred locations, on the basis of which the Irish post-glacial vegetation history was redefined. Many of these studies related to archaeological sites or finds, such as at Lough Gur, County Limerick (Mitchell 1954a) or at Littleton Bog, County Tipperary (Mitchell 1965).

By the 1950’s Alan Smith, under the auspices of the Nuffield Foundation, the forerunner to the Palaeoecology Centre at Queen’s University Belfast, had begun to investigate evidence for the earliest agriculture in Ireland. The advent of radiocarbon dating enabled Smith, and his then student Jonathan Pilcher, to associate alterations in the pollen record with the now renowned archaeological sites of Ballynagilly and Beaghmore, County Tyrone (Pilcher 1969; Pilcher *et al.* 1971; Pilcher and Smith 1979).

Smith (1970) also drew to attention the possibility of anthropogenic impact upon the natural environment prior to the onset of agriculture, by correlating peaks of microscopic charcoal deeper in sediments to Mesolithic forest fire events, suggestive of deliberate burning to open or maintain woodland clearings.

The 1980's saw the establishment of the Palaeoenvironmental Research Unit at the National University of Ireland, Galway. Michael O Connell and later Karen Molloy contributed significantly to the study of prehistoric farming in the west of Ireland (e.g. Molloy and O'Connell 1987; 1991; 1995b; O'Connell 1990; O'Connell and Molloy 1988; 2001), in particular their palynological studies relating to pre-bog field systems in Counties Mayo and Galway. Ann Lynch's (1981) investigations at various locations in Cork and Kerry aided the reconstruction of vegetation history in the south-western region, while Mitchell (1989) explored the complex history of anthropogenic interaction with the natural environment on Valencia Island, County Kerry. This work has more recently been expanded on by the investigations of Tim Mighall and others (Mighall and Lageard 1999; Mighall *et al.* 2008) in relation to Bronze Age copper mines at Mount Gabriel and Fraser Mitchell (1988; 1990a; 1990b; Mitchell and Cooney 2004) in the Killarney woodlands.

Valerie Hall (1989; 1990; 1994; 2003), of Queen's University, focused attention towards reconstruction of landscape change in the Historic period. This was aided by the identification of Icelandic tephra horizons of known chronology, Hekla in 1104 AD and Öræfajökull in 1362 AD. Thus, the pollen records could now be compared within a robust chronological framework. More recent work has been conducted by Gill Plunkett in relation to land-use patterns in the Middle and Late Bronze Age (Plunkett 2009a). This work has investigated the relationship between patterns in material culture production, the palynological record and socio-political conditions (Plunkett 2009b).

Special mention must be given for the Lisheen Mine Archaeological Project (Gowen *et al.* 2005). Undertaken in advance of mine expansion works at the Lisheen raised bog complex, this study represents arguably the finest example of multi-proxy palaeoenvironmental research conducted in Ireland. With an amalgamation of archaeological, landscape, palynological and palaeohydrological analyses, it clearly demonstrated the benefits for a synthetic approach to archaeological and palaeoenvironmental research. The interdisciplinary approach to this project enabled the results of the archaeological excavations to be placed within a palaeoenvironmental context, illustrating how the natural environment and in particular the bog's development influenced anthropogenic activity at the site and *vice versa*.

Interdisciplinary palaeoecological and archaeological research has remained very much to the forefront in prehistoric landscapes studies in recent times. Numerous recent palaeoenvironmental projects have focussed on the reconstruction of past ecological change and anthropogenic impact within diverse and visible archaeological landscapes. The work of Overland (2007; Overland and O'Connell 2008), in collaboration with detailed archaeological research (O'Brien 2009), on upland farming and settlement the Beara peninsula and research by Ghilardi (2012; Ghilardi and O'Connell 2012; Ghilardi and O'Connell 2013) and Stolze (2012a; 2012b; Stolze *et al.* 2012; Stolze *et al.* 2013a) in Sligo have demonstrated the benefits of such an approach.

1.3.2. Previous palynological research in the study region.

The earliest palaeoecological research carried out in the region was dominated by two academics, Knud Jessen (1949), Professor of Botany at the University of Copenhagen and Professor G.F. Mitchell (1951; 1954a), of Trinity College Dublin. Jessen together with his then assistant, Mitchell, at the invitation of the Committee for Quaternary Research in Ireland undertook field-work on the Quaternary Geology of Ireland during 1934 and 1935. The programme's aim was to inspect a series of Irish peat-bogs for the advancement of Late-glacial and Holocene studies on the development of flora and climate. Although rudimentary in comparison to later palynological works this research substantially contributed to the understanding of the post-glacial vegetation history of Ireland.

These investigations were followed over the next few decades by the work of Watts (1963; 1964; 1966) in Kerry and Limerick, (Welten 1952), Vokes (1966) and Bryant (1974) in Kerry. However, these mainly focussed on Late-glacial or Late-Midlandian sequences, 14,200 to 10,000 BP, and with the exception of Vokes (1966) and Welten (1952) provided little information about the period under consideration in this thesis.

The work of Lynch (1981) at Cashelkeelty, Dromatouk and Dromteewakeen 1 in County Kerry, in addition to two sites, Cullenagh and Maughanasilly in west Cork, were to have a profound influence on palaeoecological studies in the region. The identification of cereal pollen grains from a 3m peat core at Cashelkeelty, with a corresponding radiocarbon date of 4950 – 4470 BC (Waddell 2010), suggested a much earlier date than the archaeological record for the introduction of farming.

Palaeoecological research after 1981 can be neatly divided along geographical lines, namely the separate works of Barnosky (1988) and Dodson (1990) on the Dingle peninsula, the research of Cunningham *et al.* (1999) and Overland (2007; Overland and O'Connell 2008) on the Beara Peninsula, and that of Coxon (1985; 1983) and Mitchell (1989), in addition to the investigation of second millennium AD deposits by Cole and Mitchell (2003) and Hall (2003) on the Iveragh peninsula. Numerous pollen studies have been conducted in the Killarney region by Healy (1987), Mitchell (1988; 1990a; 1990b; 1993) and Mitchell and Cooney (2004), amongst others, while research by Almgren (1989; 2001; Ahlberg *et al.* 2001) has focussed on the archaeologically rich landscape around Lough Gur.

In this research two new palaeoenvironmental studies were undertaken at Arderrawinny in the south-west of the region and Lough Cullin in the south-east (see **Section 2.4.3.**). Previous palaeoenvironmental research in the vicinity of Arderrawinny consisted of the two undated pollen diagrams from Ballyally Lough and Lough Ine (Buzer 1980) to the east and the more recent works at Mount Gabriel (Mighall and Lageard 1999) and Cadogan's Bog (Mighall *et al.* 2004; 2008) to the north of Arderrawinny. In the south-east of the region previous palaeoenvironmental research consisted of interglacial profiles from Ballyline (Coxon and Flegg 1985), Newtown (Watts and Ross 1959) and Kilbeg 1 (Jessen *et al.* 1959) and 2 (Watts and Ross 1959), in addition to unpublished palaeoenvironmental reports from Newrath site 34 (Timpany 2009), Roathe house (Klimaschewski 2009), Kilkenny courthouse (Stefanini 2009) and Woodstown (Farrell and Coxon 2004). The results of these regional studies and their relationship to this previous research is outlined and discussed in **Chapters 5** and **6**.

1.3.3. Current understandings of the Mesolithic/Neolithic transition

Archaeological and palaeoecological research over the last few decades has greatly enhanced the understanding of the transition to the Neolithic in Ireland (e.g. Cooney 2000; O'Connell and Molloy 2001; McSparron 2008; Smyth 2006; 2007; 2014; Cooney *et al.*

2011; McClatchie *et al.* 2014; Whitehouse *et al.* 2014). Contrasting opinions of the precise mechanism of the transition are still debated by those who have emphasized the role of indigenous populations as the primary drivers of this change (Thomas 1988; 2004; 2013), and those who have advocated the abrupt appearance of distinct Neolithic material culture and practices associated with 'colonising farmers' (Rowley-Conwy 2011; Sheridan 2003a; 2003b; 2004; 2010).

Whatever the actual mechanisms by which Neolithic practices arrived on the island, Cooney *et al.* (2011) have indicated a permanent Neolithic presence by *c.*3800 cal BC. These practices are defined by the adoption of a subsistence economy dominated by domestic flora and fauna (Zvelebil and Rowley-Conwy 1984), in addition to the presence of ceramics, polished stone and flint axes, rectangular structures and monumental architecture. Numerous major projects have significantly enhanced our understanding of the Early Neolithic in Ireland (e.g. Smyth, 2006, 2007, 2010; Bradley, 2007; Cooney *et al.* 2011), whilst the application of large-scale archaeological dating programmes using Bayesian statistical modelling has provided finer-resolution chronologies for the start of the Neolithic practices (McSparron 2008; Cooney *et al.* 2011; Schulting *et al.* 2012; 2017; Schulting 2014; McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016).

The rectangular timber house, approximately 90 of which have been recorded (Cooney 1983; 2000; Grogan 1996; 2002; Smyth 2006; 2007; 2011; 2014), has become viewed as the typical settlement feature of the Irish Early Neolithic. The orthodox view is that these structures functioned primarily as domestic dwellings (Smyth 2014) centred around a sedentary way of life (McClatchie *et al.* 2014). The rectangular houses have been dated to a tight 'House Horizon' towards the end of the 38th century cal BC on the basis of an initial Bayesian analysis of 18 published 'gold standard' radiocarbon dates from short-lived materials (McSparron 2008), with further refinements by Cooney *et al*. (2011, 598)

Portal and court tombs belong to the same period, although neither of these monument types have been as thoroughly dated as the settlement sites. The chronology of portal tombs is particularly uncertain, although there is an emerging consensus that they fall comparatively early in the Neolithic (Kytmannow 2008; Lynch 2014) and possibly even earlier that the timber house structures (Schulting 2014). Court tomb construction appears to have been contemporary with the occupation of houses (Schulting *et al.* 2012), while their use continued for far longer than that of the rectangular houses.

Considerable strides have also been made through the work of the Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* project in better understanding the timing and nature of the adoption of agricultural practices in Ireland (McClatchie *et al.* 2014). Brown (2007) suggested that cereal cultivation arrived in Britain and Ireland after *c.*4000 cal BC, with only very limited evidence of cultivation between 3950 – 3800 cal BC, and a marked increase from 3800 cal BC. McClatchie *et al.* (2014) have refined the date for the start of arable activity in Ireland further to the middle of the 38th century cal BC, similar to the date for the start of the Neolithic more broadly of Cooney *et al*. (2011).

In contrast, very little is known about the exploitation of animals during this period (McCormack 2007). The main domesticates utilised appear to have been cattle, sheep/goat and pig, while wild mammals are also represented, including bear, wild cat, deer, rodent, wolf and bird, but again dating is an issue. The perplexingly early date for the remains of a domesticated cow from Ferriter's Cove, County Kerry (Woodman *et al.* 1999), which represents the earliest evidence for the presence of reportedly domesticated animals for the islands of Ireland and Britain, is one which raised questions of the nature of the adoption of Neolithic practices in the region. Its presence hints at the possibility of an earlier phase of introduction and/or colonization in the south-west than is evidenced in the archaeological record elsewhere.

Hints of an earlier transition to agriculture have also been postulated within the palaeoenvironmental record. However, these controversial records of possible pre-'Elm Decline' cereal pollen from a variety of sites (e.g. Lynch 1981; Edwards and Hirons 1984) have not been confirmed with dated archaeobotanical remains and thus remain questionable (Monk 2000; McClatchie *et al.* 2014). Palaeoenvironmental research in the west and north of the island demonstrate strong evidence for extensive forest clearance during the Mesolithic/Neolithic transition (e.g. Molloy and O'Connell 1995b; Ghilardi 2012; Chique *et al.* 2017), but elsewhere the situation is much less clear, with very low levels of activity (e.g. Mighall *et al.* 2008).

The major palynological event associated with the onset of agriculture, traditionally placed at the start of the Neolithic in Ireland, is the mid-Holocene 'Elm Decline'. This is characterised by a decline in elm in many pollen diagrams across north-western Europe and was viewed as a 'catastrophic, uniform phased event' (Parker *et al.* 2002, 28). More recent analysis by Whitehouse *et al.* (2014) in Ireland and Griffiths and

Gearey (2017) in north-east England have however, questioned the synchronous nature of this event. Despite this, the 'Elm Decline' is frequently accompanied by the first indisputable evidence for woodland clearance and agriculture (e.g. Mitchell 1942; O'Connell 1980; O'Connell *et al.* 1988; Molloy and O'Connell 1991; Fossitt 1994; Heery 1997; Connolly 1999; Brown *et al.* 2005; Selby *et al.* 2005; Caseldine and Fyfe 2006; Molloy 2008; Ghilardi and O'Connell 2013; Molloy *et al.* 2014) and has thus been coincidentally linked to anthropogenic activities by Whitehouse *et al.* (2014, 196).

1.3.4. Current gaps in knowledge

While the Mesolithic/Neolithic transition has attracted much archaeological and palaeoenvironmental research over the past few decades, the timing and nature of this process has yet to be fully elucidated. As outlined in the previous section, a number of recent projects (e.g. Bayliss *et al.* 2007; Whittle *et al.* 2011) have demonstrated the pivotal role that Bayesian chronological modelling has played in not only providing a more robust chronological sequence for various aspects of the Early Neolithic archaeological record (e.g McSparron 2008; Schulting *et al.* 2012; McClatchie *et al.* 2014), but also for a robust integration of these archaeological features with complementary palaeoenvironmental records (e.g. Gearey *et al.* 2009; Schmid *et al.* 2018).

While the application of the Bayesian approach has revolutionised archaeological dating methods and greatly enhanced the understanding of the chronology of the arrival of Neolithic practices, the relationship between this and past ecological change is still poorly understood. This thesis represents the first explicit use of the Bayesian approach to provide statistically robust comparisons between radiocarbon dated palaeoenvironmental records and independently dated archaeological sequences across the Mesolithic/Neolithic transition in Ireland. The paramount importance of refined and detailed chronologies in both archaeological (Bayliss *et al.* 2007) and palaeoenvironmental (Blaauw *et al.* 2018) reconstructions is well established, however, the integration of the two can provide more robust assessments of the potential relationships between anthropogenic activity and palaeoecological changes (cf. Gearey *et al.* 2009). Despite the application of Bayesian analytical methods in the assessment of aspects of the Early Neolithic archaeological record, either independently (e.g. Cooney *et al.* 2011; Schulting 2014) or in correlation with the available palaeoenvironmental datasets (Whitehouse *et al.* 2014), the full potential of this approach in deriving statistically meaningful correlations between these complementary datasets has remained rather underutilised.

The previously mentioned Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (Whitehouse *et al.* 2014), while undertaking Bayesian analysis in relation to refining the chronology of the Early Neolithic archaeological record and discussing this in relation to remodelled dates for palynological 'events' often associated with the Mesolithic/Neolithic transition, did not fully utilise the methodological approach. As outlined in **Sections 2.4.6.** and **7.2.**, the Bayesian approach allows for a quantitative, statistical assessment to be made between the *posterior density estimates* for the palynological 'events' and the independently dated archaeological evidence for human activity. In particular, in determining the relationship between the palynological signal for the timing of ecological changes, such as the mid-Holocene 'Elm Decline' and woodland clearance, and the identified archaeological evidence for the adoption of Neolithic practices. The usefulness of this approach is shown to stretch beyond merely determining the relative order of different 'events' but it can also be employed to inform broader interpretation of the process of Neolithisation in the region.

1.4. Structure of the thesis

This thesis consists of nine chapters, including this introduction chapter, and four appendices. **Chapter 2** outlines the methodologies adopted to achieve the research aims of the project outlined in **Section 1.2.** In this chapter the various methodological approaches undertaken for both the palaeoenvironmental and archaeological analysis undertaken as part of this research are outlined and discussed.

Chapter 3 provides a detailed overview of the archaeological background to the period. In this chapter the defining elements of what constitutes the Neolithic in the study region, in addition to the prevailing interpretations of the process by which Neolithic practices began are outlined and discussed.

Chapter 4 provides a detailed analysis of the chronology for the start of the Early Neolithic in the region. In this chapter the results of the various Bayesian analytical models, which have explored the chronology of the archaeological evidence for the start of Neolithic practices in the region are outlined and discussed.

Chapters 5 and **6** outline the results of the palaeoenvironmental analysis which has been undertaken as part of this research. The palynological assessment of a lake core form Lough Cullin, County Kilkenny is outlined and discussed in **Chapter 5**, while the palynological assessment of a small mire at Arderrawinny, County Cork is outlined and discussed in **Chapter 6**. The results of these analyses are discussed in relation to previous palaeoenvironmental research undertaken in the region and elsewhere, with particular reference to the palaeoecology of the sites during the Mesolithic/Neolithic transition.

Chapter 7 explores the chronology of the Mesolithic/Neolithic transition in greater detail, with the results of the integrated Bayesian analysis of the palaeoenvironmental and archaeological data outlined and discussed. This chapter also explores the nature of the mid-Holocene 'Elm Decline' on both a regional and island-wide scale to assess the reliability of this 'event' as a chronological proxy for the start of the Neolithic.

Finally, in **Chapter 8** the overall results of this research are discussed, and final conclusions are made in **Chapter 9**. These chapters will outline the principal findings of this project and provide new hypothesis into the process of Neolithisation in southern Ireland.

Chapter 2 - Sites and Methods.

2.1. Introduction.

The following chapter discusses the basic methods applied to address the overall research aims and objectives of the project outlined in **Chapter 1**. This chapter begins by outlining the geographical remit of this study, before detailing the various methodological approaches adopted in the palaeoenvironmental analysis undertaken as part of this research, including site selection criteria, laboratory and analytical procedures and data presentation. Finally, the methodologies applied to the collating and interpretation of the archaeological record, including the Bayesian approaches adopted are outlined and discussed.

2.2. Defining the region.

The study area, defined as southern Ireland, encompasses the southern-most counties of Ireland, namely Counties Kerry, Cork, Limerick, Waterford and the southern parts of Counties Kilkenny and Tipperary. The inclusion of sites from the latter two counties allowed for a broader spatial understanding of the Neolithic in the region. The restriction of the study area to modern county boundaries would have been unwise as relevant sites in the latter two counties would have encompassed the same archaeological landscapes. The region is therefore demarcated by an imaginary line from the River Shannon to the River Barrow (see Figure 2.1).

2.3. Archaeological analysis.

The following section discusses the Early Neolithic archaeological remains identified in the region. This section also outlines the methodologies employed in the identification, selection and categorisation of Early Neolithic archaeological sites as part of this study. It also explores the criteria, principles and approaches adopted in exploring the chronology of the Early Neolithic archaeological assemblage of the region.

2.3.1. Sources of archaeological information.

The main source of information used to facilitate this thesis were the final excavation reports for the motorway, gas pipeline and various private infrastructural developments within the study region. These excavation reports are the primary repository for all contextual and dating information used in this research. This source of information was obtained through consultation with Transport Infrastructure Ireland (TII), formally the National Roads Authority (NRA), Record of Monument and Places (RMP, see https://www.archaeology.ie), Department of the Culture, Heritage and the Gaeltacht archives (https://www.excavations.ie), county development plans, and various literature resources including published excavation summaries.

Furthermore, a number of unpublished excavation reports from various commercial archaeological companies including Judith Carroll/Network Archaeology, Irish Archaeological Consultancy Ltd., Headland Archaeology/Rubicon Heritage, Archaeological Consultancy Services Ltd., TVAS (Ireland) and Valerie J. Keeley Ltd. were also consulted. These published and unpublished excavation reports were investigated to identify all sites of confirmed or likely Early Neolithic date within the region. A database of all identified sites was compiled, with particular reference placed upon the radiocarbon datasets from excavated archaeological sites. Additional information about radiocarbon dates was obtained by consulting the *Catalogue of Radiocarbon Determinations and Dendrochronology Dates* online database (Chapple 2018) and the Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* supplementary material published by Whitehouse *et al.* (2014).

2.3.2. Bayesian analysis of archaeological datasets.

Introduction

The basic principles of the Bayesian approach to the interpretation of archaeological or palaeoenvironmental chronological data are based on the Bayes' theorem (Bayes 1763). The application of the Bayesian approach to archaeological datasets operates under the principle that while the calibrated age ranges of radiocarbon measurements estimate the calendar ages of the samples themselves, it is the dates of archaeological events associated with these samples that are of paramount important to archaeological interpretation (Bayliss *et al.* 2007, 5). Bayesian analysis provides quantitative estimates of the dates of such archaeological events (posterior beliefs) through the combination of two strands of data, absolute or scientific dating evidence ('the standardised likelihoods') and relative dating information, such as the stratigraphic relationship between contexts from which the dates were derived ('prior beliefs') (*ibid.*). These posterior beliefs are then expressed as '*posterior density estimates'*, and are by convention, always expressed in italics.

The Bayesian approach

The construction of Bayesian chronological models requires the inclusion of two elements, standardised likelihoods, and prior beliefs. The standardised likelihoods component of the Bayesian model are dates derived from scientific methods (radiocarbon dates or dendrochronological dates) and also possibly dating information derived from documentary sources or artefact typology. In this study, all of the standardised likelihoods come from calibrated radiocarbon dates.

Prior beliefs consist of two strands of information, informative and uninformative prior beliefs. Informative prior beliefs represent specific and definitive archaeological information derived from the relative dating evidence provided by the stratigraphic relationships between the samples from which the radiocarbon dates were obtained. This type of information generally relates to the sequence of deposition of the archaeological contexts ordered within a Harris matrix (Bayliss *et al.* 2011, 27).

Uninformative prior beliefs represent the inclusion of assumptions about the mathematical distribution of the archaeological events in the phase of activity from which the radiocarbon dates are derived (Bayliss 2007, 5; Bayliss *et al.* 2011, 21-27). For robust Bayesian models it is essential to impose such a distribution to counteract the statistical scatter on the radiocarbon measurements. Such statistical scatters occur as radiocarbon dates come with errors, and therefore a proportion of the probability distributions of the calibrated radiocarbon dates pertaining to a particular phase of activity, will be earlier or later than the calendar span of that phase. If this scatter is not taken into consideration, the model may produce results for the start or end of archaeological activity which are earlier or later than was actually the case (Bronk Ramsey 2000; Steier and Rom 2000). The approach adopted in this study is to therefore assume that the archaeological events which have been sampled for radiocarbon dating are distributed uniformly (Buck *et al.* 1992).

Once the components of the Bayesian model have been assembled, the standardised likelihoods obtained, and the prior beliefs defined, the OxCal program calculates the probability distributions of the individual calibrated radiocarbon results (Stuiver and Reimer 1993). The model will then attempt to reconcile these distributions with the prior information by repeatedly sampling each distribution to create a set of solutions consistent with the model structure. This is done using the Markov Chain Monte Carlo (MCMC) random sampling technique (Bronk Ramsey 1995; 2009a) which generates a representative set of possible combinations of dates. This process produces a *posterior density estimate* of each sample's calendar age, which occupies only part of the calibrated probability distribution. These *posterior density estimates* are not absolute and will change as additional radiocarbon dates are added or the Bayesian models are rerun from different perspectives.

Should specific events, such as the beginning or end of an activity at a given site, not be dated directly by radiocarbon measurements, it is possible to calculate more accurately a distribution for such events using the Bayesian method (Bayliss and Woodman 2009, 109), provided that a sufficient number of radiocarbon determinations (at least five) exist for the site. These posterior beliefs are not dependant on any one particular radiocarbon date, but rather on the entire assemblage of dates from the phase. Additionally, comparison of these *posterior density estimates* allows an estimation to be made of the duration of a particular phase of activity or activities and the time elapsed between the end of one and start of another phase of activity. These estimates can then be compared to calculate and refine the probability distributions of activities and events across a site or the beginning of a particular practice across a region.

To assess the reliability of the models, two statistical indices were used by OxCal; (A:) and ($A_{overall}$:), both of which have an index of agreement threshold value of 60% (Bronk Ramsey 1995, 429). The (A:) index indicates the robustness of agreement between the *posterior density estimate* and the standardised likelihood from which it derives. In this study this represents the level of agreement between the individual calibrated radiocarbon dates and the resulting *posterior density estimate* from the Bayesian model. Where there is a low (A:) index of agreement, it may merely indicate that the radiocarbon date is a statistical outlier, however very low agreement may suggest that a sample is residual or intrusive.

The ($A_{overall}$:) tests the overall index agreement which is calculated using the individual agreement indices. This provides a general measure of the consistency between the prior information and the standardised likelihoods. This is essentially the agreement of the combined *posterior density estimates* generated within the model, and their agreement with the overall Bayesian model. It is therefore possible, particularly within large datasets, for one or more radiocarbon dates to fall below the required (A:) index of agreement but for the ($A_{overall}$:) index of agreement to be greater than 60%, which would indicate that the overall model is robust. To determine if each model is stable and robust, OxCal also conducts a convergence test, which measures how quickly the MCMC sampler is able to produce a representative and stable solution to the model. In practice, a model with a poor convergence value (<95%) is deemed unstable and results should not be used.

Bayesian chronological modelling employed in this study

For the purpose of this thesis, a series of Bayesian models were constructed to help refine the chronology of sites to allow for a more robust interpretation of the start of Early Neolithic practices across the region. While previous studies have explored the chronology of the Early Neolithic in Ireland (eg. Cooney *et al.* 2011; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016), it was deemed essential to undertake a Bayesian modelling program of the Early Neolithic archaeology of the specific region to allow for the robust integration of this dataset with the palaeoenvironmental reconstructions undertaken as part of this research.

This Bayesian modelling program was undertaken for two reasons, firstly to provide a robust, regional comparative study between the palaeoenvironmental analysis undertaken as part of this research and the Early Neolithic archaeological record. The necessity of Bayesian models which accurately reflect the start of the Neolithic on a scale which is relevant to the palaeoenvironmental analysis undertaken here was imperative to ensure a robust interpretation of both datasets. Furthermore, this allowed for the integration of both datasets within the Bayesian modelling framework, which enabled the results of the palaeoenvironmental investigations, and the chronology of palynological ‘events’, to be explored in relation to the relevant archaeological record. This resulted in the elucidation of potential regional nuances in the introduction of Neolithic practices.

The main objectives for this Bayesian program were therefore to:

- provide a more precise and robust dating for start of activity at each site;
- estimate the duration of the use of each site;
- provide an estimate for the start of the Neolithic in the region;
- check the chronological relationship of the Early Neolithic archaeological record and palynological ‘events’ associated with the introduction of agriculture.

As this study sought to refine the date range for the introduction of Neolithic practices in southern Ireland, it was essential that radiocarbon dates incorporated into the Bayesian model reflected occupation and activity on site. Therefore, three basic criteria for assessing a sample were followed:

- radiocarbon dates were derived from short-lived, single entity material, rather than long-lived charcoal (cf. Ashmore 1999);
- the sample had not been contaminated by a carbon containing material;
- the sample was securely associated with the archaeological activity of interest (cf. Waterbolk 1971).

The implementation of these criteria enabled a more refined and accurate date for the start of the Neolithic in the region to be determined. However, Bayesian chronologies are conceptual models and so the *posterior density estimates* produced by the modelling of the dataset in this study are not absolute. They are interpretative estimates which are understood and discussed within the context of the queries proposed for this study and so will inevitably change if modelled from a different perspective. Therefore, various different models were undertaken to test varying hypothesis concerning the uptake of Neolithic practices in the region. These are outlined in **Chapters 4** and **7.**

2.4. Palaeoenvironmental analysis.

The following section outlines the methods undertaken as part of the palaeoenvironmental analysis in this study. This section discusses the criteria employed in selecting suitable sampling sites to address the aims and objectives of this research. A brief description of each sampling site selected is also provided, in addition to the fieldwork, laboratory and analytical methodologies utilised in this study.

2.4.1. Site identification and surveying.

A preliminary pre-selection of sites was conducted based on known wetland sites within the region. This desk-based survey was conducted using a variety of cartographic and online resources to create an overall index of past and present wetland sites within the region. These included Google Earth, OS Mapping, Geology maps, the map of Irish wetlands and the Derived Irish Peat Map (Connolly 2009). A rapid field survey of potential sites was undertaken which led to the exclusion of some sites and the identification of two locations which constitute the sampling sites of the present study. Sites were surveyed by probing at transects across each sampling site, at each point recording the depth of sediment using a 2.5cm diameter Eijelkamp gouge. Surveying and depth-probing was used to locate the deepest sediment accumulation at each site in order to obtain the longest possible chronology and maximise the temporal resolution of the pollen stratigraphic record.

2.4.2. Sampling site selection criteria

Basin diameter

Firstly, it was necessary to understand and apply the principles of pollen source area-basin diameter relationships. Considerations of which allowed for fine-spatial resolution palynological investigations of vegetation cover in close proximity to archaeological contexts. This reduced the relative source area of pollen (RSAP) to the immediate vicinity of Neolithic sites enabling local anthropogenic activity to be better defined (cf. Jacobson and Bradshaw 1981; Bradshaw 1988). By interpreting these in relation to investigations form larger sites, human impact was assessed from a local to a regional scale and determinations on whether impacts of the scale exhibited in the period can be detected at a regional level were made.

Pollen source area as a methodological approach for site selection and factors which affect the interpretation of palynological data need to be addressed in palaeoecological reconstruction. In this respect, small basins (*c.*50 – 100m radius) are more suitable in that, although the area of vegetation represented in the pollen record is more restricted than those of larger sites (Prentice 1985), more limited spatial impacts can be better detected, and the Mesolithic/Neolithic can thus be more securely interpreted as a record of the changes in surrounding woodland communities.

In general, small, clearly delimited sampling basins were the preferred sites to maximise the magnitude of local pollen deposition, thus providing pollen records that are sensitive to local vegetation change. Sites considered therefore included basins up to *c.*100m in radius. This was considered of prime importance for obtaining palynological records at temporal and spatial scales appropriate to archaeological interpretation.

Proximity to archaeological sites.

An additional criterion was applied to the selection of potential sites, which was to place these sites within close spatial proximity to extant or excavated Early Neolithic archaeological remains. In this study the spatial scale of the palaeoecological work was such that it was able to contribute directly to nearby archaeological research allowing closer integration between disciplines. Such interdisciplinary research provided greater insights into the relationship between humans, vegetation and land management during the Early Neolithic.

Transect of sites across the region.

The third criterion was to select sites along a latitudinal transect across the study region. This introduced the larger scale environmental gradients of geomorphology, topography and edaphic conditions, between the more upland settings to the west and lowland conditions to the east of the region. This allowed the range of environmental factors influencing vegetation development to be investigated, and their effects on species composition, woodland structure and human activity to be explored.

The east-west transect across the region also allowed the gradient in Early Neolithic archaeological visibility to be incorporated into this study. The greater visibility of Early Neolithic archaeological sites in the east of the study region may reflect a recovery bias within the distribution of such activity, possibly due to increased infrastructural development in this region than in the west, and the incorporation of palaeoenvironmental sampling sites from both areas allowed for an assessment of whether this accurately reflects the Early Neolithic anthropogenic activity in the region.

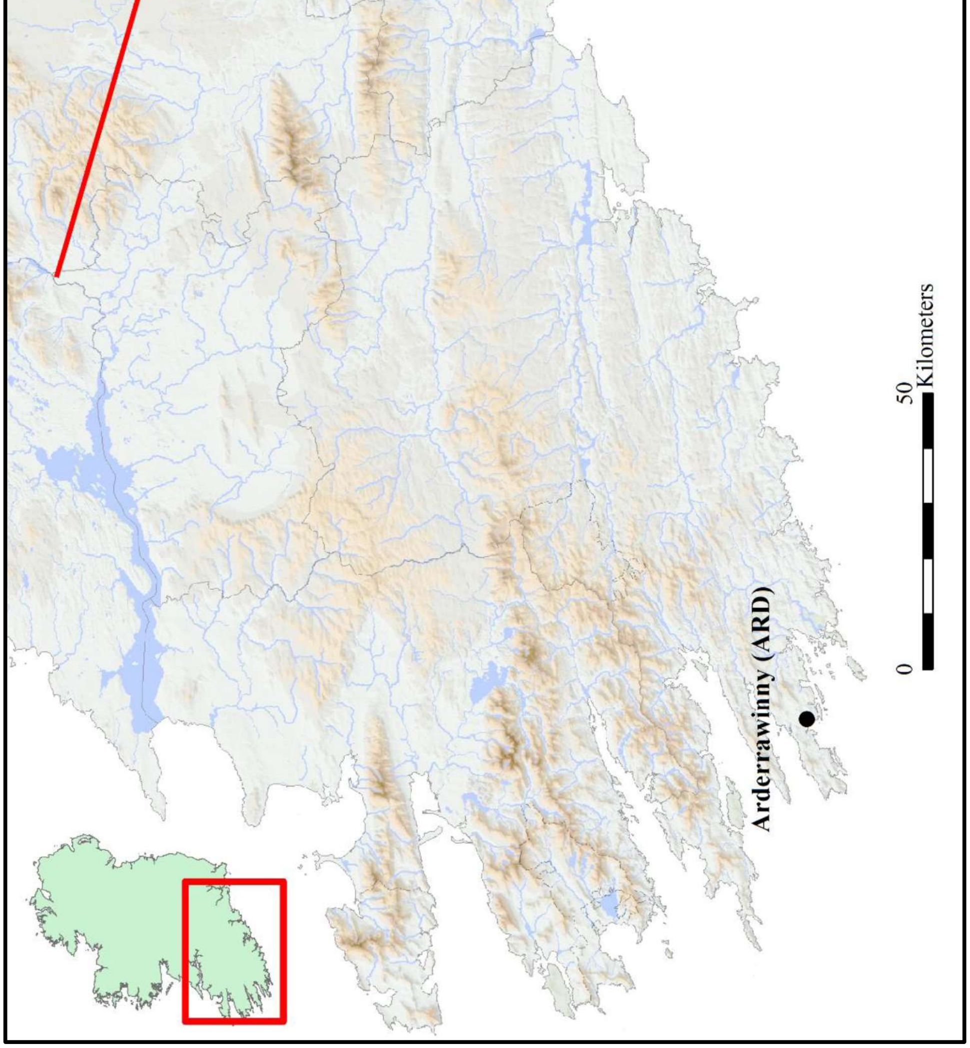

Figure 2.1 Map of study region and palaeoenvironmental sites

2.4.3. Sampling sites.

Two palaeoenvironmental sampling sites were selected on the basis of these three criteria. The location of the sites is illustrated in Figure 2.1. Estimates of source area of each sampling site are based primarily on the lake surface simulations of Sugita (1994) and Sugita *et al.* (1999), as few papers provide quantitative estimates of source area for more than a single basin diameter and, with the exception of research on small hollows, none relate to terrestrial sediments. Source area estimates are of radius beneath a closed canopy, since little information is available for open landscapes.

Arderrawinny.

The sampling site (ARD) in the townland of Arderrawinny is located near the town of Schull on the Mizen peninsula, County Cork (Latitude 51° 58' N, Longitude 9° 54' W). The site is at an elevation of approximately 20mOD and is overlain on Devonian Old Red Sandstone, while the primary soil type of the region is peaty podzols. The core was extracted from a small mire located beside a small lake at the junction between the hillslopes and valley floor. The site is therefore exposed to water and sediment influx through flooding and hillslope runoff. To the west of the coring site location a large ridge of exposed bedrock, covering *c.*180 hectares runs for *c.*2.4km north-east/south-west. A similar ridge also runs to the immediate south of the site. The projecting hillside adjacent to the sampling site may provide some shelter from prevailing south-westerly winds. The present-day bog surface is dominated by *Sphagnum* spp., *Myrica gale* and *Calluna vulgaris*, with *Typha latifolia* around the lake edge. *Rubus, Salix* and *Ulex* grow on dryer ground at the edge of the mire. To the east of the sampling site *c.*2.6 hectares of grass land has been reclaimed and is currently used for pastoral agriculture.

A 5.26m core was extracted using a Russian head corer and sub sampling (1cm^3) was conducted at 2cm, 4cm and 8cm intervals. As the peat-filled basin is small, *c.*45m in radius, the pollen profile ARD can be expected to accurately reflect local vegetation and land use dynamics within a *c.*300 – 400m radius based on the site radii simulations of Sugita (1994). The precise area depends on the numerous factors including atmospheric conditions and the dispersal capacity of the various pollen taxa. Vegetation outside this radius is also reflected but to a much lesser extent, in particular non-arboreal pollen

(NAP), which has a much-reduced dispersal capacity compared with the arboreal pollen (AP) component (Sugita 1994; Sugita *et al.* 1999). The openness or patchiness of the vegetation will also be a defining factor as these favour the dispersal of the NAP component, which is the main indicator of anthropogenic activity (Hellman *et al.* 2009).

The archaeological landscape in the vicinity of the sampling site exhibits signs of continuous occupation from the Neolithic period. A total of 39 archaeological sites are identified within a 2km radius. A Neolithic presence is exemplified by a portal tomb in Arderrawinny townland and Chalcolithic/Early Bronze Age activity by the 2 wedge tombs in the townlands of Altar and Toormore. 3 standing stones in the townlands of Gunpoint, Lissacaha and Beakeen and a further unclassified cairn in Toormore also likely date to prehistory. The remaining 32 sites are either undated or relate to Early Medieval or post-Medieval occupation in the region. The sampling site is located *c.*0.5km west of the portal tomb in the townland of Arderrawinny and an undated enclosure is located *c.*0.8km to the north east. Two further megalithic structures are identified within a 2km radius of the sampling site, the Early Bronze Age wedge tombs in the townlands of Altar and Toormore are 1.1km and 1.5km, from the sampling site respectively.

Figure 2.2 Location of Arderrawinny coring site (ARD)

Figure 2.3 Exposed bedrock outcrop north of the coring site

Figure 2.4 Extraction of pollen core from Arderrawinny

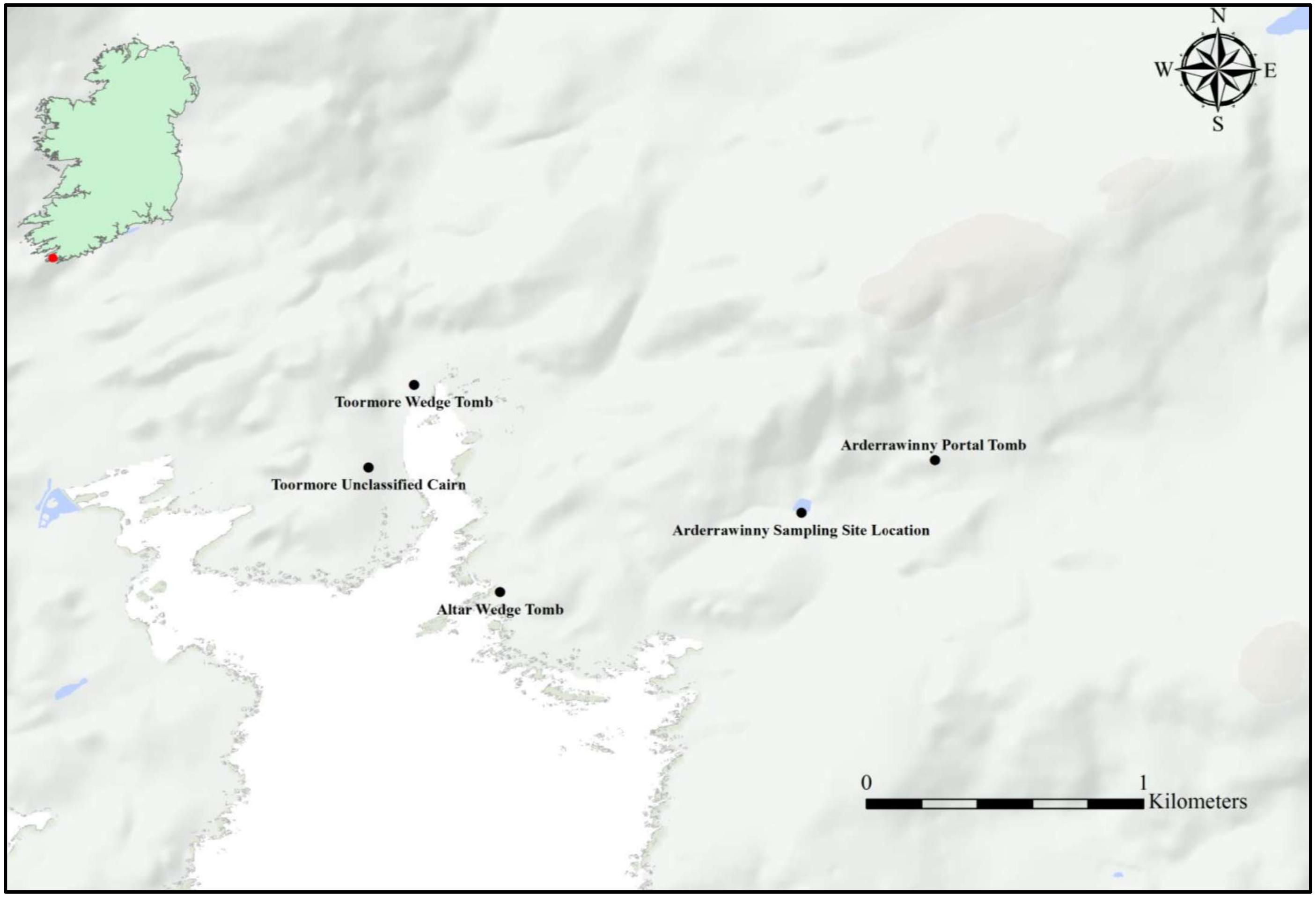

Figure 2.5 Megalithic tombs within a 1.5km radius of Arderrawinny

Lough Cullin.

The sampling site (LC) is located within the townlands of Ballincrea, Charlestown, Gaulstown and Moanroe in south County Kilkenny (Latitude 52° 19' N, Longitude 7° 06' W). The site is at an elevation of approximately 20mOD and is overlain on Tournaisian Limestone. The principal soil type of the region consists of mineral rich brown earths and the surrounding landscape is heavily utilised for pastoral agriculture, while a growth of planted silver birch (*Betula pendula*) trees is located to the east of the lake. This sequence and loss on ignition data was provided by Dr Susan Hegarty (St. Patrick's College, Drumcondra, Dublin) for further analyses and assessment. An 8m core had been collected from this lake using a Livingstone corer from a raft positioned in the centre of the lake (Hegarty pers. comm.). The upper section of the Lough Cullin core was assessed as part of the Heritage Council, Irish National Strategic Archaeological Research Programme (INSTAR)-funded project *Settlement and Landscape in Later Prehistoric Ireland: Seeing beyond the site* (Becker *et al.* 2016), while the lower section was assessed as part of this research. As the lake basin is small, *c.*100m in radius, the pollen profile LC can be expected to accurately reflect local vegetation and land use dynamics within a *c.*400 – 500m radius based on the site radii simulations of Sugita (1994).

Figure 2.6 Approximate location of Lough Cullin coring site (LC)

The archaeological landscape in the vicinity of Lough Cullin exhibits a continuous human presence from the Early Mesolithic to modern times. However, as the palaeoenvironmental record evaluated in this chapter only covers the Mesolithic and Neolithic, sites from these archaeological periods are discussed here. A total of 38 archaeological sites have been identified within an approximate 20km radius of the site, 10 of which date to the Mesolithic (Early and Late) and the remaining 28 are from the Early, Middle or Late phases of the Neolithic. The majority of Mesolithic sites in the area have been identified as such based on the recovery of diagnostically Mesolithic artefacts, primarily lithics, with no evidence of what could be deemed as settlement activity. This is unsurprising considering the transient nature of Mesolithic communities (cf. Woodman 2015). An Early Mesolithic presence has been identified at Granny (sites 1 & 21) (Gleeson and Breen 2006a; 2006b), Killoteran (site 9) (Russell 2010b) and Woodstown (sites 2 & 6) (O'Connell 2009; Russell and Harrison 2011), while a Late Mesolithic presence was identified at Granny (site 22) (Gleeson and Breen 2006b), Mullinabro (site 4) (Wren 2006a), Newrath (site 34) (Wilkins *et al.* 2009) Rathpatrick (site 17) (Wren 2006b).

The remaining 28 Neolithic sites belong to the Early (23 sites), Middle (3 sites) and Late (2 sites) Neolithic respectively. The overwhelming archaeological evidence from this period would therefore appear to date from the Early Neolithic (*c.*3750 – 3550 cal BC). Twelve of these sites are portal tombs, which while unexcavated, likely date to the Early Neolithic (see **Chapter 3**). Four Early Neolithic rectangular house sites, Earlsrath (site AR035) (McKinstry 2010a) Granny (site 27) (Hughes 2006), Kilkeasy (Monteith 2010) and Newrath (site 37) (Wren 2006c), have been excavated in the vicinity of Lough Cullin. A Late Mesolithic presence is also suggested at Newrath (site 37) due to the recovery of charred hazelnut shells which returned a date range of 4490 – 4340 cal BC (5587±40, *UB-6642*). An Early Neolithic presence was also identified at the ephemeral occupation sites excavated at Ballykeoghan (Wren 2010), Bawnfune (site 2) (Lennon 2009), Butlerstown North (site 2) (Johnston and Tierney 2010*)*, Graigueshoneen (Tierney 2005), Newrath (site 35) (Wilkins 2006) and Scart (Monteith 2011).

Following this Early Neolithic period evidence for anthropogenic activity becomes much more muted in the archaeological record around Lough Cullin with four Middle Neolithic and three Late Neolithic sites recorded. A Middle Neolithic presence is suggested by the two passage tombs at Carriglong and Harristown, the radiocarbon dated ephemeral occupation site at Ahanaglogh (Tierney 2005) and also at Newrath (site 35) (Wilkins 2006). Evidence for Late Neolithic activity was also recorded at Graigueshoneen (Tierney 2005), Rathpatrick (site 17) (Wren 2006b) and Scart (Monteith 2011) demonstrating a re-occupation of earlier site in the Late Neolithic.

Figure 2.7 Arial view of Lough Cullin to the North

Figure 2.8 Arial view of Lough Cullin to the South

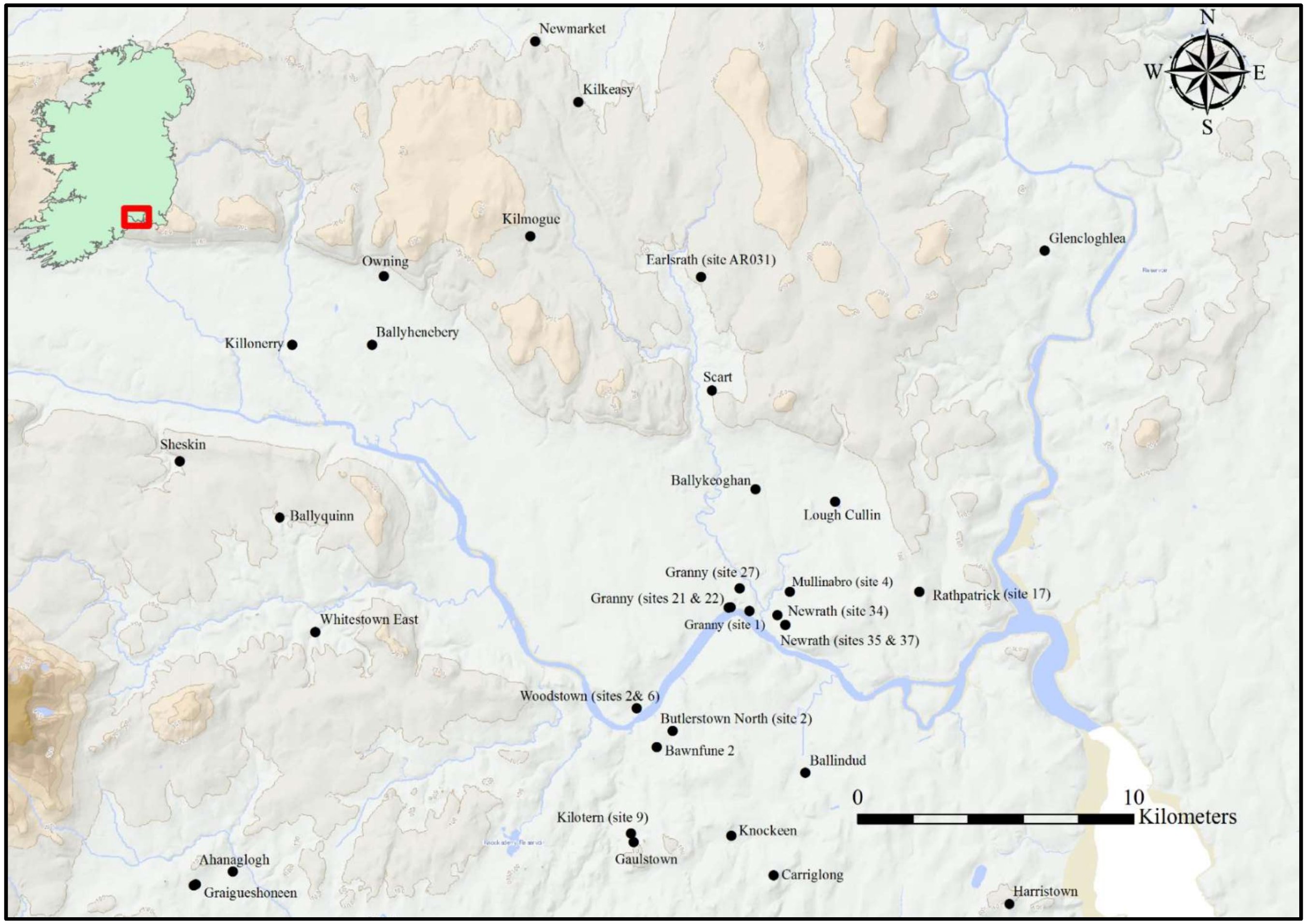

Figure 2.9 Mesolithic and Neolithic archaeological sites within a 20km radius of Lough Cullin

2.4.4. Sampling strategies.

This section outlines the methods and procedures employed for extracting and sub sampling sediments from each core.

Sediment sampling.

A series of cores were sampled using a 50cm long Russian corer with a cylinder diameter of 6cm. All cores were placed in labelled guttering and sealed in plastic wrap in the field and stored at 4^{o}C in the laboratory. The cores were cleaned in the laboratory and the stratigraphy was described using the Troels-Smith (1955) recording system. Sub sampling for pollen analysis was carried out at depth intervals of 2cm, 4cm or 8cm.

Laboratory procedure.

Pollen preparation followed standard techniques including NaOH digestion, HF treatment and acetylation (Moore *et al.* 1991). Pollen concentrations were established by adding a known concentration of *Lycopodium clavatum* spore (batch number 177745) to the samples before treatment (Stockmarr 1971). (For a full outline of the laboratory procedures employed see Appendix A-1)

2.4.5. Data collection and presentation.

This section summarises the procedures used for analysing and presenting the palaeoecological data used in the research. Methods of pollen identification and presentation are discussed in the relevant sections.

Pollen identification and taxonomy.

Pollen counts were made using a Leica DM 1000 LED microscope at x400, x800 and x1000 magnification under oil immersion for critical examination of pollen sculpture and measurement of pollen grains. A minimum terrestrial pollen sum of 300 pollen grains, excluding spores and aquatics, was employed (Maher Jr 1972). Pollen grains were identified mainly using the key of Moore *et al.* (1991) and the pollen reference collection at the University College Cork, with reference to Faegri *et al.* (1989). The nomenclature employed followed Stace (1997) with suggestions from Bennett *et al.* (1994). The designation '*cf*' indicates that this was the closest identification possible but not an exact match, or that type material was not available to confirm the identification. *Cerealia*-type pollen was distinguished from other Poaceae pollen based on size of grain pore and annulus and were presented in a separate curve (cf. Beug 2004). Monoporate pollen grains of less than 39µm were placed in the Poaceae (non-cultivated grass) curve. The difficulty in the separation of *Myrica gale* and *Corylus avellana* pollen resulted in these grains being classified as *Corylus avellana*-type (Edwards 1981). For the saccate grains of *Pinus* the individual air sacs were counted and subsequently divided by two, in order to estimate the number of grains.

Presentation of pollen data.

The programmes TILIA and TILIA - GRAPH (Grimm 2004) were used to construct spreadsheets and pollen diagrams. The pollen sum consists of total land pollen grains (TLP), excluding aquatics and spores. In the calculation of percentage values, all taxa included in the pollen sum are expressed as a percentage of the TLP sum, according to the equation:

$$Pt = \frac{Ct}{TLP} x100$$

Where *Pt* is the percentage values of a specific taxon, *Ct* is the count for that taxon and *TLP* is the total number of pollen grains counted for that sample. The percentage values for non-pollen taxa such as spores was calculated as TLP + taxon or group and was calculated with the formula:

$$Pnpt = \frac{Cnpt}{TLP + Snpt} * 100$$

Where *Pnpt* is the percentage values of a specific taxon outside the total pollen sum, *Cnpt* is the count for that non-pollen taxon, *TLP* is the total number of pollen grains counted for that sample and *Snpt* is the sum of the taxa pertaining to that component. Pollen concentration was also calculated in TILIA, using the equation:

$$CONt = \frac{Ct * CONly}{Cly}$$

Where *CONt* is the concentration of a specific taxon or group, *Ct* is the pollen count for that taxon or group, *CONly* is the concentration of *Lycopodium* spores initially added to the sample and *Cly* is the *Lycopodium* spore count. All concentration data is expressed as grains per cm^{-3}.

Zonation of pollen diagrams.

Pollen assemblage zones (PAZs) were identified by visual inspection of the pollen diagrams and were determined by changes within the vegetation composition. The PAZs were defined with the prefix 'ARD' for Arderrawinny and 'LC' for Lough Cullin.

Loss on Ignition.

Loss on Ignition (LOI) analysis was undertaken to estimate the ratio of inorganic (minerogenic) to organic component of sediments. In this analysis, a sample of known dry weight is burned and the resultant weight loss of the remaining material is expressed as a percentage of initial dry weight using the equation:

$$\%Org = \frac{(Ma - Mb)}{Ma} * 100$$

Where *Ma* is the weight of the sample (minus the weight of the crucible) before ignition, *Mb* is the weight of the sample (minus the weight of the crucible) after ignition and *%Org* is the percentage of the organic content of the sample.

Laboratory procedures follow standard procedures (Heiri *et al.* 2001) outlined in Appendix A-2. Loss on ignition diagrams were constructed using the TILIA program (Grimm 2004). Zonation of the loss on ignition data followed the pollen assemblage zones.

2.4.6. Detrended Correspondence Analysis

The pollen datasets were subjected to Detrended Correspondence Analysis (DCA) (Hill 1974; Hill and Gauch 1980) implemented using the computer programme PAST (Hammer *et al.* 2001). The Detrended Correspondence (DCA) module in PAST uses the same 'reciprocal averaging' algorithm (*ibid.,* 4) as the program DECORANA (Hill and Gauch 1980).

Detrended correspondence analysis (DCA) was developed to overcome the distortions inherent to correspondence analysis (CA) ordination, in particular the 'arch effect' (Gauch *et al.* 1977), where one-dimensional gradients are distorted into an arch on the second ordination axis and to prevent samples from being unevenly spaced along the first axis (Kent and Coker 1992, 223).

DCA overcomes these problems by flattening this arch and rescaling the positions of samples along an axis. It starts by running a standard ordination (CA or reciprocal averaging) on the data, to produce the initial 'arch' in which the first ordination axis distorts into the second axis. The 'arch' results from the mathematical structure of the CA ordination and is not related to the data incorporated in the analysis. It arises because the process constrains the second axis to be uncorrelated with the first axis rather than independent of it, which results in an inability to interpret both axes independently of each other (Hill and Gauch 1980, 48). DCA eliminates this 'arch' by ensuring that subsequent axes are statistically independent not only to the first axis, but also to a quadratic and a cubic on that axis, while also insisting that the subsequent axes are drawn so that at any point along the first axis, the mean value of the subsequent axes is approximately zero. The process of subtracting a local mean value for an appropriate segment of the first axis is referred to as 'detrending'. In effect, if there is arch present, it is flattened onto the lower order axis.

A second problem of CA which is overcome by the use of DCA is that it acts to preserve ecological distances between samples. In CA sample pairs with equivalent compositional distances appear farther apart in the middle of, rather than toward the ends of, the first axis (*ibid.*, 50-51). DCA therefore rescales the axis so that the ends are no longer compressed relative to the middle, so that each DCA unit approximates to the same rate of turnover all the way through the data. The rescaling of an axis is accomplished by equalizing the weighted variance of taxon scores along the axis segments.

This is achieved by dividing the first axis into segments and rescaling each segment to have a mean value of zero on the second axis, effectively preserving the ecological distances of samples and flatting the ‘arch’. The detrending process is sensitive to the number of segments and the default value suggested by the program PAST (Hammer *et al.* 2001) is 26. DCA therefore arranges the data so that the most similar taxa are close together and the dissimilar further apart, assuming that the species abundance have a unimodal optimum along underlying gradients (Kent and Coker 1992, 224). In the analysis undertaken as part of this study, rare taxa, which appear in less than 5% of the total samples (cf. Hill and Gauch 1980, 56) or those which are unlikely to reflect a local presence, have been excluded to prevent distortion of the data.

2.4.7. Radiocarbon dating and Bayesian modelling of palaeoenvironmental data.

Samples for radiocarbon dating were extracted on the basis of changes in the pollen diagrams. The samples for radiocarbon dating consisted of plant macrofossils (where available and identifiable) and bulk sediment samples, with duplicate measurements on the humin (the acid and alkali-insoluble) and humic (alkali-soluble, acid insoluble) fractions (Cook *et al.* 1998, 21) obtained in many but not all instances, due to financial restraints. The humic acid is formed during humification and the humin may be most representative of the original plant material (Brock *et al.* 2011, 551), although it may still be contaminated with in-washed or intrusive carbon (e.g. Dugmore *et al.* 1995; Waller *et al.* 2006; Brock *et al.* 2011). These duplicate measurements were therefore obtained to insure the accuracy of sediment derived radiocarbon determinations (cf. Brock *et al.* 2011). Using the *R_Combine()* function in OxCal (Bronk Ramsey 2009a) the statistical consistency (Ward and Wilson 1978) of these paired humin and humic fraction was assessed. Duplicate measurements were deemed to be statistically consistent if they had a combined ‘T’ Value of less than 5.

The resulting radiocarbon determinations are presented as conventional radiocarbon ages (Stuiver and Polach 1977) and are quoted in accordance with the international standard established by the Trondheim Convention (Stuiver and Kra 1986). The calibrations of these results have been calculated using the published datasets, IntCal13, (Reimer *et al.* 2013) and the computer program OxCal v4.3 (Bronk Ramsey 1995; 1998; 2001; 2009a). The calibrated date ranges cited are quoted in the form recommended by Mook (1986), with the end points rounded outward to 10 years. The calibrated date ranges have been calculated using the maximum intercept method (Stuiver and Reimer 1986) and the graphical distribution of the calibrated result were derived from the probability method (Stuiver and Reimer 1993). All radiocarbon dates are cited at two sigma, (95.4% confidence) unless stated otherwise.

In order to better refine the chronology of palynological 'events' and to extend the chronological framework to 'events' which fall between dated horizons in any given stratigraphic sequence, a number of 'age-depth' model techniques were considered, including linear interpolation, splines and linear regression (Bennett 1994) to mixed-effect models (Heegaard *et al.* 2005) and fuzzy regression (Boreux *et al.* 1997). However, in this study a Bayesian approach (see **Section 2.4.2**. below) was employed (Buck *et al.* 1992). As this study sought to evaluate the chronological relationship between the archaeological record (see below and **Chapter 4**) and certain palynological 'events' in a more statistically robust fashion it was also decided that this study would refrain from the use of simplified 'age-depth' models and instead the chronology of all 'events' are expressed as 95.4% probability *posterior density estimates.*

The approach uses the software OxCal v4.3 program (Bronk Ramsey 2009a), and the *P-Sequence* function (Bronk Ramsey 2008) was chosen to allow for a 'Poisson' process or a potentially random rate of sediment accumulation. The prior information for the deposition rate was defined as log_10(*k*/*k*_0) where k_0 = 1, which allows *k* to take any value from 0.01–100cm^{-1}. The *k* factor is estimated based on the relationship between the number of depositional events and the overall stratigraphic process. The value used was estimated from the radiocarbon dates following the approach outlined in Blockley *et al.* (2007; 2008).

The ranges quoted in italics are *posterior density estimates*, derived from this Bayesian mathematical modelling of the radiocarbon chronology (Bayliss *et al.* 2007). The command *Outlier()* was used in OxCal (Bronk Ramsey 2009b) to identify any measurements which were statistically defined as an outlier at a 0.05 probability (1 in 20). The *Date()* function was used to extrapolate a *posterior density estimate* for palynological features at given depths from the resulting *P_Sequence*, while the duration or time interval between events was estimated by using the *Difference()* command. The statistical probability of an 'event' being before, after or contemporaneous with another 'event' was estimated by using the *Order()* command, which builds up a matrix of the relative order of all pairs of ‘events’.

2.4.8. Additional sources of palaeoenvironmental information

The main source of palaeoenvironmental information used to facilitate this thesis was the IPOL database (Stefanini and Mitchell 2011), previous postgraduate research and unpublished reports from various commercial archaeological companies. These sources were consulted to establish a database of all palynological profiles which encompassed the Mesolithic/Neolithic transition in Ireland.

These sites were then utilised for a chronological and palynological comparison of the palaeoenvironmental analysis undertaken in this study. For a robust chronological comparison of the chronology of palynological ‘events’ associated with the beginning of Neolithic practices (the mid-Holocene ‘Elm Decline’, initiation of a continuous *Plantago* curve etc.), certain parameters were established to determine which sites could be incorporated into this study. Firstly, sites lacking radiocarbon dates were excluded from this analysis. Secondly, sites which had an insufficient number of radiocarbon dates for Bayesian modelling to be undertaken were also excluded, unless the ‘events’ in question had been directly dated.

Sites which had a sufficient number of radiocarbon dates for Bayesian analysis were modelled using the programme OxCal v4.3 (Bronk Ramsey 1995; 1998; 2008; 2009a) and IntCal13, (Reimer *et al.* 2013). For each of the sequences a model was produced assuming a ‘Poisson’ process which treated the sediment accumulation process as being random. Deposition models were constructed to allow for flexibility in the estimation of sediment formation over the depth of each core, by averaging the values of the rigidity of the model (*k* value) of between 0.01 and 100cm^{-1} (Bronk Ramsey and Lee 2013). Where there were age inversions in the sequences, formal outlier analysis was undertaken to identify radiocarbon dates which were subsequently removed from the models (Bronk Ramsey 2009b) and are indicated by the ‘?’ symbol. The *Date ()* function was used to extrapolate a *posterior density estimate* for palynological features from the resulting *P_Sequence* at the depths quoted in the original publication or depths suggested in this analysis.

However, while certain sites had sufficient radiocarbon determinations for Bayesian modelling to be undertaken, the resolution of said dates was such that these were insufficient to effectively assess and counteract the statistical scatter of radiocarbon dates, resulting long tails on the *posterior density estimate.* The date ranges of these *posterior density estimates* were therefore too wide to be of use in refining the chronology of the palynological events concerned. Thus, a further criterion was established in which the date ranges/*posterior density estimates* for palynological 'events' had to be within the threshold of *c.*600 years, for inclusion in the model.

Chapter 3 - The Mesolithic/Neolithic Transition in southern Ireland.

3.1. Introduction.

This chapter provides an overview of the forager to farmer transition in Ireland, with particular emphasis placed upon the archaeology of the Early Neolithic in southern Ireland. Attention is given to previous and current understandings of the Neolithic period, including debates about the mechanisms of adoption, places of origin and defining features of the Irish Neolithic. To better contextualise the Neolithic in the region reference is made to certain sites outside the study area, while a brief outline of the preceding Mesolithic period is also presented. An overview of the chronology of the Neolithic is referred to briefly here and discussed in greater detail in the next chapter.

The chapter then explores the Early Neolithic in the region in more detail, primarily the timber houses and sites associated with the Carinated Ware tradition. Different aspects of the Neolithic, from the adoption of agriculture, sedentism, the construction and use of monuments, new forms of lithics, to the introduction of pottery are discussed. A discussion of the varied interpretative approaches applied to this subject is included, with details of how the Mesolithic/Neolithic transition has been researched in Ireland and beyond also outlined.

3.2. First settlers: Ireland in the Early Mesolithic.

Hunter-gatherer communities of the Mesolithic represent the earliest human occupation in Ireland, arriving around 8000 cal BC (Woodman 2015, 119)[1]. After the last glacial maximum Ireland was cut off from Britain and Europe, *c.*16000 BP, which resulted in limited diversity of flora and fauna on the island. This floral and faunal impoverishment greatly restricted the variety of mammals for Mesolithic people to hunt. The most striking omission from the range of available fauna is *Ungulata,* in particular elk, deer and wild cattle (Woodman and McCarthy 2003). The paucity in the range of potential 'game' is likely to have greatly impacted on the subsistence practices of Early Mesolithic populations in Ireland. Animals that could be hunted by Mesolithic populations in Ireland

[1] See Woodman (1998; 2015, 171-175) and Wickham-Jones and Woodman (1998) for discussion on the potential evidence for an Irish Palaeolithic.

included wild boar, brown bear, otter, lynx, stoat and perhaps wild cat (Woodman 2015, 26). Various species of avifauna, freshwater and migratory fish and foraged foods must also have provided some sustenance. These include trout, salmon, eel, bass and wrasse. Bird bones from woodpigeon, woodcock, capercaillie and grouse are present in Mesolithic sites, in addition to those of ducks and divers such as mallard, teal, widgeon and the red-throated diver have been excavated (Waddell 2010, 6). Hazelnuts are frequent on Mesolithic sites, while wild fruits and edible wild plants also supplemented the diet.

Diagnostic Early Mesolithic tools are small flint tool implements, known as ‘microliths’ which were composite implements used as projectiles for hunting, as well as a range of cutting tools for butchering, preparing hides and wood working. The raw material for producing stone tools in the Mesolithic was flint and chert for small tools and rocks of volcanic origin for stone axe-heads. In the initial stages of colonisation Mesolithic populations appeared to have preferred to use flint as the main raw material for tool production and because this stone has a limited distribution away from the north-eastern region of Ireland the main source was on the coast (Woodman 2015, 33). Similarities between the lithic assemblages of both the Early Irish and British Mesolithic suggest these colonists probably travelled by boat to the island of Ireland from Britain (*ibid.*, 185).

Early Mesolithic populations were transient and have left little trace on the landscape, however sites which have been identified are frequently found in coastal areas or further inland along river valleys. Of the limited examples excavated, two main sites Mount Sandel, County Antrim (Woodman 1985), and Lough Boora, County Offaly (Ryan 1980) have dominated discussions of the Early Mesolithic in Ireland. The Mount Sandel excavations produced evidence for four egg-shaped hut structures, approximately 6m in diameter, in addition to numerous refuse and storage pit features (Woodman 1985), and probably represents a base camp occupied and returned to several times during the year (Waddell 2010, 7-8). The application of Bayesian modelling has revised the date range for activity at the site to between *7790–7635 cal BC* and *7570–7480 cal BC* (Bayliss and Woodman 2009, 115), which represents the earliest conclusive evidence for human occupation in Ireland. The Lough Boora excavation produced evidence of a lake shore site that was eventually encroached by bog (Ryan 1980). The dates returned for the site was broadly contemporary with those of Mount Sandel, but no dwelling structures were identified. The site was interpreted as a temporary camp site, with the dominance of eel bones suggesting a summer occupation.

A clear indication from bones discovered at Mount Sandel and Lough Boora is the large reliance on fish for sustenance during the Early Mesolithic. The recovered faunal remains from both sites demonstrates an overwhelming dominance of fish bones, 81% at Mount Sandel (Woodman 1985, 73), primarily salmonoids, with lesser amounts of bass, eel and plaice/flounder, and 68% at Lough Boora (Van Wijngarden-Bakker 1989, 125-133), principally eel and brown trout. This indicates a strong reliance on maritime and riverine resources during the period *c.*8000 – 4000 cal BC, in marked contrast to the Mesolithic in Britain. In the Early Mesolithic site of Starr Carr in Yorkshire, large quantities of deer are present as are elk, wild cattle and pig (Frazer and King 1954; Smith 1992, 112), yet despite its location in a similar setting to that at Lough Boora very little bird and no fish remains were identified. Similarly, the contemporary site of Thatcham (Wymer 1962; Healy *et al.* 1992), overlooking a tributary of the River Kennet in Berkshire, again produced mammal and bird remains but limited evidence of the reliance of fish for nutritional diversity (Smith 1992, 122), indicating a greater reliance on aquatic resources during the Early Mesolithic in Ireland than in Britain.

Despite this apparent reliance on riverine resources at Irish Mesolithic sites mammal and avifaunal bones have also been identified. These are almost exclusively pig bones, though small amounts of hare, either dog or wolf and thirteen bird species, ranging from woodland, to river, to coastal types, were also present at Mount Sandel (Woodman 1985, 72). The level of importance played by birds and edible flora in the diet of the post-glacial settlers is at present difficult to state. Small proportions of bird bone have been identified at many Mesolithic sites but not enough to state that these constituted a significant amount to their diet. The avifaunal remains identified at Mount Sandel suggest winter occupation and consumption, in particular, mallard, teal, woodpigeon and woodcock. These species tend to migrate in large numbers in autumn and winter (*ibid.*, 72) and may have provided a dietary supplement during periods of food scarcity and when fishing was limited due to seasonal availability.

The same can be said for edible vegetation, as hazelnuts are ubiquitous on excavated sites, being easily stored and a valuable source of fat and protein. Despite the meagre evidence, it must be assumed that fruit, roots and fungi were also exploited (Waddell 2010, 19) but due to the nature of preservation, remains of these would be very unlikely to have survived. Evidence for the use of flora at Mount Sandel is demonstrated in the recovery of large quantities of charred hazelnuts, while wild pear/crab apple and water lily were also recorded (Woodman 1985, 80)

Early Mesolithic settlement had a seasonally shifting pattern where the exploitation of different food sources at different times of the year required a certain amount of movement (Waddell 2010, 20-21). The evidence from Mount Sandel would indicate this operated as a base camp connected to procurement sites that were temporarily occupied to procure the local resources. Mount Sandel may represent a permanent settlement occupied for much, if not all of the year. The presence of foetal pig bones and hazelnuts would indicate that the site was occupied during late Autumn and Winter, while the presence of salmon and eels indicate Spring and Summer occupation at the site. Occupation at Lough Boora on the other hand may have been more seasonal, with eels present in lakes in summer and hazelnuts suggesting autumn occupation. This may have been a temporary site with the inhabitants moving elsewhere as the seasons dictate.

3.3. Ireland in the Later Mesolithic.

The Later Mesolithic (*c.*6000 – 4000 cal BC) has been contrasted to the Early Mesolithic in terms of a perceived lack of base camps, possibly indicating a more mobile society, or simply a lack of evidence for similar sites to Mount Sandel. The Later Mesolithic evidence is often characterised by isolated finds, specialist sites in coastal areas, or sites with no lithics but returning Later Mesolithic radiocarbon dates. The perceived lack of Later Mesolithic base-camps has raised questions as to whether this represented increased mobility in the Later Mesolithic, whether the island was more sparsely populated or whether later comparative sites simply have not yet been identified (Woodman 1986, 13; 1992, 302). This increased mobility is question by Cooney and Grogan (1999, 21-23) who suggested that the Later Mesolithic in Ireland would more than likely have been comparable with the European model of the sedentary complex hunter-gatherer. The apparent shift to coastal locations in the Later Mesolithic compared to the proceeding phase may also reflect rising sea levels disguising earlier evidence rather than a change in settlement patterns.

Lithic production changed from the use of microliths to larger flakes and in the final stages of the Later Mesolithic, tools known as 'Bann Flakes' or butt-trimmed, leaf-shaped points (Woodman 2015, 141; 231-232; Woodman *et al.* 2006, 61) which appear to be unparalleled in mainland Britain or continental Europe (Waddell 2010, 22). Later Mesolithic communities continued to practice a hunter-gather lifestyle and maritime resources would have continued to play a significant role in the diets of these communities. Later Mesolithic wooden platforms have been noted at Clowanstown, County Meath (Mossop and Mossop 2009) and at Mitchelstown East, County Limerick (Woodman and Anderson 1990, 386) and appear to relate to fishing, while the wooden trackway at Inch Strand near Lough Gara, County Sligo (Fredengren 2002, 120) may also relate to the exploitation of aquatic resources.

Faunal remains from Ferriter's Cove, County Kerry (Woodman *et al.* 1999) demonstrated the importance of costal resources during this period, where evidence from midden investigations indicate a strong economic reliance on mollusc procurement both for consumption and as bait for fishing (McCarthy 1988; McCarthy *et al.* 1999). At Rockmarshall, County Louth (Mitchell 1947; 1949; 1971) a wide range of shellfish including oyster, periwinkles and carpet shells was noted, also crab claws, fish and a 'scrap' of seal bone suggests occasional exploitation of larger marine wildlife. Other shell middens excavated on Dublin Bay, notably Sutton (Mitchell 1956) and Dalkey Island (Liversage 1968; Leon 2005) again exhibited large quantities of molluscs and fish remains. The recovery of Later Mesolithic fish traps on the Liffey Estuary at North Wall Quay (McQuade 2008; McQuade and O'Donnell 2006) and at Clowanstown in County Meath (FitzGerald 2007; O'Sullivan and Stanley 2008; Mossop and Mossop 2009) further demonstrate the pervasiveness of aquatic resources for dietary sustenance at the time, which may account for the apparent prevalence for coastal site locations during the period.

However, in light of stable isotope analysis it is now argued that similarly dated Later Mesolithic human remains had a differing food intake. The analysis of human remains from Rockmarshall gave a result of -18.1‰, which does not indicate a predominantly marine diet (Woodman *et al.* 1997, 143; Woodman 2015, 285). The Ferriter's Cove human remains indicated a marine based diet (-14‰ & -14.1‰), while the Killuragh Cave, County Limerick remains indicated a terrestrial diet (-21.96‰ & -21.3‰) (Woodman *et al.* 1999, 143), although the extensive reliance on eels may have masked a coastal component (Woodman 2015, 285). This would indicate that Later Mesolithic communities may have moved seasonally between the coast and inland while others may have 'subsisted exclusively in the interior of Ireland' (Woodman *et al.* 1999, 143). Later Mesolithic communities may have procured both marine and terrestrial resources, which could possibly suggest the utilisation of inland areas and coastal locations as part of a seasonal hunter-gatherer strategy. It is also possible as Cummings (2017, 18-19) suggests that different Later Mesolithic communities specialised in exploiting different environments, with extensive exchange networks between groups. This resources specialisation has been suggested at Moynagh Lough, County Meath (Bradley 1999; McCormack 2004), where despite its location, no aquatic or avifaunal remains were identified, while McCormack (2007, 81) notes that all faunal remains were that of adult male or young wild boar and could indicate the selective culling of non-breeding females.

3.4. Island isolation or part of a wider world?

While the previous two sections have briefly addressed the Mesolithic period in Ireland, the following section explores the final centuries prior to the start of the Neolithic. This section considers the evidence, or lack thereof, for potential exchange networks or connections between Later Mesolithic communities in Ireland and the wider world. As will be discussed later, the arrival of Neolithic practices, whether through the diffusion of ideas (eg. Thomas 1988; 2013) or the movement of people (eg. Sheridan 2004; 2010) must have originated from outside of Ireland and it is therefore essential to assess whether this resulted from a long process of overseas contact or an abrupt arrival following several millennia of isolation.

It has been suggested that the distinct nature of stone tools used in Ireland indicate little contact between Later Mesolithic people in Ireland and those in Britain (Woodman 1981; Saville 2004; Kimball 2006). In Ireland, the diagnostic Later Mesolithic object is the 'Bann Flake', which has been used to classify a broad range of butt trimmed lithics (Woodman *et al.* 2006, 61; Kador 2010; Woodman 2015, 141; 231-232). The development of this lithic technology contrasts with the continued use of microlithic technology in Britain (Butler 2005) or the trapezoids, rhomboids and '*Feuilles de Gui*' of continental European Later Mesolithic assemblages (Jacobi 1976). This may suggest a degree of insularity in the Irish Later Mesolithic where hunter-gatherer groups did not maintain exchange networks or long-distance contacts with populations in Britain or continental Europe. This stylistic variation, and the apparent distinctive insular characteristics of the Irish lithic assemblage (Woodman and Anderson 1990), is suggested by Cooney (2000, 13) to indicate a lack of sustained contact with Britain or continental Europe, a view supported by Sheridan (2003a, 4) who postulates that there is no evidence for a 'significant amount of prior contact between communities either side of the Channel (or indeed the Irish Sea)'.

However, one particular anomaly in this emphasis on lithic technology to support an isolationist view of the Irish Later Mesolithic is the evidence from the Isle of Man. The dominant lithic of the Later Mesolithic assemblages of the island is also the butt-trimmed 'Bann Flake' (McCartan 2004). This indicates that a degree of contact, either through kin-based social interactions or material exchange network must have existed between the two islands during the Later Mesolithic. Alternatively, as Cummings (2017, 20) suggests, the use of lithic styles may be an unreliable method of understanding zones of contact. This view is shared by Thomas (2004), who questions the reliance on the distributions of artefact types as an indicator of the intensity of social interaction, arguing;

'There is no sense, then, in which the existence of mutually exclusive assemblages of artefacts in different geographical areas can be taken as an index of the degree of contact between the human populations involved.' (Thomas 2004, 114)

Thomas postulates his argument with reference to the work of Gendel (1984) who suggests that variations within the lithic assemblages of Later Mesolithic groups in North-East France, Belgium, the Netherlands and western Germany, relate to the development of increasingly distinct social groups and that differences in style were maintained despite interactions between neighbouring groups (*ibid.*, 131).

A further aspect of the Later Mesolithic in Ireland which needs to be addressed in relation to perceived cultural isolation is the issue of stone axe-heads and whether these represent evidence for long-distance contacts between Ireland and continental Europe. Ground and polished stone axe-heads are frequently identified in Irish Later Mesolithic contexts (Woodman 1978, 109-114; 2015, 146-148; Woodman *et al.* 1999, 63-65) and are 'one of the most consistently occurring aspects of the Irish Mesolithic' (Woodman *et al.* 1999, 79). Although pre-Neolithic examples have not been recorded in England

(Saville 2004, 93), comparable objects are identified in Wales (David and Walker 2004, 325-327) and possibly Scotland (Saville 2009), which may indicate contacts across the Irish Sea, while polished stone axe-heads are known from Mesolithic contexts in continental Europe (e.g. Welinder 1977; Price 1983; 1991; Fischer 2003; Karlén and Larsson 2007). These axes are often regarded as evidence for the existence of contacts and exchange networks between hunter-gatherer and early farming communities in Northwest Europe (Kador 2010, 151). It is therefore conceivable that the presence of polished stone axe-heads in Later Mesolithic contexts in Ireland could be indicative of cross-channel interactions at this time, whether through exchange networks with stone axe-heads moving between groups or with the inspiration for such objects coming from social interactions with communities in continental Europe. Thomas (2013) takes this a step further and suggests that jadeite axes, commonly view as evidence of exchange networks in the Neolithic, were already much older when deposited and were imported in the Late Mesolithic. However, jadeite axes are unknown in Mesolithic contexts in either Britain or Ireland, which would cast doubt on this suggestion.

Whether the presence of Later Mesolithic interaction across the Irish Sea or with continental Europe can be inferred from the similarities in the use of stone axe-heads or rejected based on the perceived insular development of 'Bann Flake' lithic technology, undisputed evidence for contact can be found in the discovery of domesticated faunal remains at a few Later Mesolithic sites in Ireland. The presence of bones of domesticated animals dating to the final centuries of the Mesolithic from Ferriter's Cove (Woodman *et al.* 1999), Kilgreany cave (Woodman *et al.* 1997), Sutton (Mitchell 1956), Dalkey Island (Liversage 1968; Leon 2005), and possibly Lough Kinale (Fredengren 2009), raise interesting questions about the nature of external contact at the end of the Irish Late Mesolithic. As referred to above, *Ungulata* were absent from the Irish post-glacial assemblage and the presence of cattle bones would demonstrate that some form of contact with the continent must have taken place (Woodman and McCarthy 2003, 36). The cattle bone from Ferriter's Cove, dated to the latter half of the 5th millennium cal BC, represents the earliest evidence for the presence of domesticated animals in Ireland or Britain (Woodman *et al.* 1999), with mainland Europe proposed as the most likely source of these animals at the time. Alternative suggestions of whether this represents an early phase of 'failed' colonisation (Sheridan 2010), or the remains of a joint of meat transported to Ireland from Britain or the Continent (Whittle 2007) have been proposed, which if accepted would indicate that some form of cross-channel interaction must have occurred towards the end of the Late Mesolithic.

While material culture has been used to infer a strong degree of isolation in the Irish Later Mesolithic (Cooney 2000; Sheridan 2004), this is very much a circular argument. 'Bann Flake' lithic technology is suggested as a sign of insularity, whereas evidence which is less likely to survive suggests the presence of interactions with populations in continental Europe. The presence of cattle in Ireland prior to the Neolithic would appear to be at odds with a Later Mesolithic which lithics suggest was remarkable insular. Therefore, the reliance upon material culture as an index of social isolation may be an insufficient determination in understanding interaction between hunter-gatherer communities in Later Mesolithic Ireland and beyond. Factors other than the lack of cross channel contact may have limited artefact mobility, while human movements and interactions need not always be marked by the transfer of material culture (Woodman and McCarthy 2003, 36). Therefore, by implication significant levels of social contact could exist even where artefacts are not being transported.

Furthermore, the correlation between the creation of a distinctive macrolithic technology and social, cultural and economic isolation of the Later Mesolithic in Ireland (Woodman 1981) may be unwise, as communities can produce distinctive, apparently insular, material culture in response to social contact as opposed to lack of contact (Robb 2001). Stylistic variation in material culture could be viewed as a means by which people might selectively signal their identities to specific target populations (Wobst 1977). Hodder (1982) demonstrated the problems with assessing group contact, identity and origin from material culture alone. His ethnoarchaeological work in the Lake Baringo area of Kenya demonstrated that stylistic variation of artefacts could be used to construct and negotiate identities in changing contexts. Social identities were being constructed and maintained irrespective of contact within and between groups and the perceived insularity of the Irish Later Mesolithic lithic assemblage may therefore not be an indication of a lack of contact with the wider world.

It is therefore highly probable that significant exchange networks were in place between Ireland, Britain and continental Europe in the latter part of the fifth millennium cal BC. The precise nature of these interactions is still open for debate, they may have be recurring or episodic, especially given the considerable social and economic changes which were occurring in north-west Europe at the time (discussed below, Cummings

2017, 41). The suggestion that Mesolithic communities in Ireland were in contact with Britain or continental Europe would be in keeping with the situation elsewhere in northern Europe (e.g. Louwe Koojimans 2007; Vanmontfort 2007; Thorpe 2015), where Later Mesolithic communities were in contact with their Neolithic neighbours. The evidence from Ferriter's Cove (Woodman *et al.* 1999) is strongly suggestive of such contacts and may represent exchange networks with Neolithic communities in continental Europe, although Sheridan (2010) and Tresset (2003) would argue this represents an early 'failed' Neolithic colonisation (see below). However, what must be borne in mind as we move to addressing the issue of the Mesolithic-Neolithic transition is that contact between those forager and farmers did not necessarily result in one specific outcome. Such contacts may have resulted in foragers adopting farming, forager not adopting farming, or a mix of both lifestyles (Cummings 2017, 41).

3.5. The Mesolithic/Neolithic transition in Ireland.

3.5.1. Introduction.

The previous sections have examined the evidence for what was occurring in Ireland prior to the fourth millennium cal BC. In the following sections the focus shifts to evaluating and discussing the start and spread of Neolithic practices across the island. In order to adequately address this topic, four questions need to be considered; how? what? where? and when?

Firstly, the question of how the Neolithic began is considered, with a discussion of the prevailing and competing perspectives of what form the process of Neolithisation took. Ultimately, Neolithic practices had to have originated from outside of Ireland and it is therefore important to consider the possible points of origin for the Irish Neolithic to better contextualise and understand its development. This section goes on to consider the precise date for the start of the Neolithic in Ireland and finally what constitutes the Neolithic and differentiates it from the Neolithic elsewhere is considered.

3.5.2. How did the Neolithic begin?

While earlier accounts tended to focus on the Neolithic revolution in terms of the defining material culture of the period (Childe 1925), the process of Neolithisation was given less consideration, viewed as either through the movement of ideas or people (*ibid.*). However, the process which led to the start of the Neolithic in both Britain and Ireland, and the precise mechanisms for the arrival of the Neolithic 'package' has been much more widely debated and contested over the past several decades. This debate has become highly polarised between those who advocate indigenous populations as the primary drivers of this cultural change, either exclusively (eg. Thomas 1988; 2013) or following initial small-scale, low profile colonisation (eg. Whittle *et al.* 2011, 853-861), and those who champion the role of continental European Neolithic colonists (eg. Sheridan 2004; 2010).

The role of migratory Neolithic Europeans was generally assumed in many early discussions on the introduction of agriculture, such as those of Piggott (1954) or Case (1969), which focused on how and when, but not whether, pioneering colonists arrived in Britain and Ireland. These studies envisaged new populations sweeping aside the preceding Mesolithic hunter-gatherers or assimilated them into the Neolithic way of life (Cummings 2017). More recent 'colonist' models have been outlined by Sheridan (2003a; 2003b; 2004; 2010), in which she is highly critical of the idea that indigenous foragers were responsible for the introduction of farming to Britain and Ireland, with little population movement involved. The typology of early megalithic construction (Sheridan 2003b, 12), pottery styles (Sheridan 2003a, 7-9) and the fully formed techniques of ceramic production (Sheridan 2004, 12) indicated the arrival of culture groups from the continent. The abrupt arrival of all things Neolithic in the first centuries of fourth millennium cal BC is argued to result from colonists and not the gradual adoption of aspects of farming by a predominantly mobile indigenous population (Rowley-Conwy 2011, 5443)

In opposition to this colonist approach it is argued that it was the transfer of ideas, along with some Neolithic 'things' which arrived from continental Europe, that was the main driver of change and not the wholesale movement of people. Thomas (2013) views the Neolithic as a change in conceptual worldview of the indigenous population, who adopted certain aspects of Neolithic culture over a long period as they saw fit. He saw no evidence of, or need for, colonising farmers in the Neolithisation of Britain and Ireland. The principal supporting argument for this is the lack of a direct analogue for the Neolithic in Britain and Ireland on the continent, and in the absence of this, the only possibility is that Mesolithic societies 'became Neolithic' (Thomas 2004, 126). This 'indigenist' approach (Zvelebil 2000, 59) does allow for a small-scale movement of people, but not the mass migratory movement as proposed by Sheridan (2003a; 2003b; 2004; 2010).

With this in mind, attempts have been made to combine the two possible scenarios for the introduction of the Neolithic. Whittle *et al.* (2011, 849-853) have argued that the start of the Neolithic was initiated by small-scale, low-key colonisation from the continent into south-east England, before spreading to other areas by fusion and integration with the indigenous population. Therefore, the Neolithic may not have been a uniform, unvarying concept, and may have taken various forms in different areas. People may have moved from continental Europe into Britain and Ireland, bringing their material culture and concepts, and at the same time, some indigenous inhabitants adopted new practices directly from Neolithic populations elsewhere. The two populations would have interacted and combined to produce a Neolithic that was initially similar but distinct (cf. Garrow and Sturt 2011; Cummings and Harris 2011; Cummings 2017).

3.5.3. Defining the Early Neolithic.

Introduction.

Despite disagreement about how the Neolithic began, there is broad agreement about the different aspects of material culture which, together with their intertwined concepts, defined the Neolithic. This section addresses these various aspects of how people lived in the Early Neolithic, with a particular emphasis on material culture, subsistence, settlement and monumentality. This includes considerations on the new forms of material culture, such as retouched lithics and ceramics, introduced at the start of the Neolithic, in addition to new plants and animals. It also outlines the evidence for houses and more ephemeral settlements in the region before addressing aspects of Early Neolithic monumentality and funerary practices.

Material culture.

The introduction of pottery and new styles of stone tools is regarded as one of the markers of the Neolithic in Ireland. One of the most common finds on Early Neolithic sites are stone tools and stone tool production waste or debitage. In the Early Neolithic stone tools continued to be made of flint, although other material such as chert and quartz are also utilised, especially in areas with limited flint supplies. The Early Neolithic saw new ways of working stone involving pressure flaking or invasive retouching (Edmonds 1995) as well as new tools being produced. The core Early Neolithic lithic assemblage, consisted of large, leaf-shaped arrowheads, scrapers, plano-convex knives and lozenge-shaped arrowheads, or possibly javelin points and is remarkably similar to British material of the same period, in striking contrast to the situation which had existed in the Later Mesolithic (Woodman 1993, 217). Stone tools were an essential part of everyday life and would have been used for a variety of different tasks. Arrowheads would have been used for hunting, to kill predators and possibly against people (Schulting 2012; Ó Donnabháin and Tesorieri 2014, 81-82; Cummings 2017, 48-49). Other tools such as scrapers, knives and piercers would have been used to work hides, procure food such as cereals and working organic material such as baskets (Hurcombe 2014).

A further characteristic form of Early Neolithic material culture is the polished stone axe-head. These were made of flint or stone, some were shaped by knapping the stone but more often they were ground or polished which created a smooth, shiny outer surface. Polishing the cutting edge of an axe increased efficiency, but overall polishing which would have been laborious and time-consuming, improved the appearance. In Ireland there is evidence that some stone axes were polished during the Mesolithic (Woodman *et al.* 1999) and stone axes continued in use well into the Bronze Age (Sheridan 1986, 27).

Image Redacted, See Hughes (2006, 62)

Figure 3.1 (1) Scrapers, (2) Leaf-shaped arrowheads from Granny, County Kilkenny (Hughes, 2006)

Provenance studies have demonstrated that some locations were highly valued as sources of raw material, with finished products often moving considerable distance from the original source of production (Clough and Cummins 1988). The largest source of stone axes in Ireland was from Tievebulliagh and Rathlin Island which was in use between the 38th and 35th century cal BC (Whittle *et al.* 2011, 794). Stone axes from these quarry sources have been identified at sites such as Gortore 1b, CountyCork (O'Donoghue 2011), with approximately 200 also recorded in Britain (Cooney 2000, 205), while British sourced Langdale Group VI axes are also recorded in Early Neolithic sites such as a tuff stone axe of possible Group VI (Langdale) type from Kilkeasy, County Kilkenny (Monteith 2009; 2010). This would indicate a considerable exchange network of material culture across the Irish Sea at this time, while the presence of jadeite axes from the Alpine region (Pétrequin *et al.* 1998, 232; Cooney 2000) indicates the presence of long distance exchange networks across continental Europe.

A stone axe was obviously a woodworking tool, but its importance in the Neolithic was greater than its mere functionality, as demonstrated by the high degree of polishing. Formal deposition of polished stone axe heads in places of significance, such as in domestic structures, megalithic tombs, rivers and bogs, was a common feature of Neolithic Britain and Ireland. Stone axes were widely available in the Neolithic and they were used commonly in daily life. Although many axes were functional items their significance could be increased depending on the size of the axes, the care taken in production or the rarity of the raw material. The functional use of the majority of axes potentially increased the significance of the more unusual stone types, adding to their symbolic role in gift exchange systems. Axe-heads may have passed from person to person over considerable distances and may have acquired great significance from their association with the people who possessed them (Edmonds 1995; 1998). Eventually axes were taken out of circulation, deposited in settlements, pits, rivers or wetlands and this act in itself would have been highly significant (Cummings 2017, 56-57).

Image Redacted, See Hughes (2006, 62)

Figure 3.2 Stone axe-head from Granny, County Kilkenny (Hughes 2006)

The recovery of polished axe-heads from foundation trenches or postholes is a well attested feature of Early Neolithic house structures (Smyth 2006), including many examples in southern Ireland. At Earlsrath, County Kilkenny (Mckinstry 2009; 2010a) a mudstone axe was retrieved from the fill of a posthole within the bedding trench of structure 1 and may suggest a deliberate act of deposition, while similar examples are recorded at Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005), Gortore, County Cork (O'Donoghue 2006; O'Donoghue and Johnston 2013), Granny, County Kilkenny (Hughes 2006) and Kilkeasy, County Kilkenny (Monteith 2009; 2010). Axe-heads recovered from a pit at Newrath 35, County Kilkenny (Wilkins 2006; Hughes *et al.* 2011), were not discarded after use in a chance location but deliberately deposited with other items of significance. They was placed in a shallow, round bottomed pit alongside a leaf-shaped arrowhead, broken pottery, a large rhyolite stone core and chipped flint pebble. The context of this material is unlikely to represent rubbish pits or casually discarded items, but may signify the ceremonial returning of this social significant material to the earth (Waddell 2010, 57), where gifts were taken out of circulation and returned to the land and the realm of the ancestors.

Pottery was a further important new technology introduced in Ireland at the start of the Neolithic. It has become one of the defining feature of early farming communities in Ireland (Waddell 2010, 50) and its use indicates and encourages sedentism by constraining mobility (Cooney 2000, 184) as early pottery vessels were heavy, fragile, lacked handles and were also round-bottomed. However, because of its durability, pottery is one of the principal artefacts to survive on archaeological sites.

Carinated Ware, which represents the earliest pottery found in Ireland (Case 1961; Sheridan 1995), was similar in style to those that found in northern Britain at the time (Sheridan 2007; Waddell 2010, 50). Pots were round-bottomed with distinctive shoulders, concave necks and with simple pointed or slightly rounded rims. Apart from some fingertip rippling or fluting executed in the wet clay before firing, decoration was usually absent and wall thickness may be no more than 5-6mm. There appears to be no evidence for an experimental phase of pottery production in Ireland, as the early pots were finely made, suggesting the people who made them were already well versed in the craft (Cummings 2017, 61). This would imply that those who made the earliest pots in Ireland were taught the practice by already knowledgeable individuals, possible through marriage exchange (Thomas 2013, 360), or the practice was introduced by migrants from the continent (Sheridan 2004; 2010). Pottery was hand-built from local clay and fired using the 'bonfire' technique, where pottery was stacked in a bonfire and not in a kiln (Müller and Peterson 2015, 591). The presence of unfired lumps of clay at Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005) and Pepperhill, County Cork (Gowen 1988, 44-51) would indicate pottery production was undertaken on site.

Pottery is found as a common deposit in both domestic and ritual sites throughout the region. They feature at timber houses and ephemeral settlement sites such as Tankardstown, County Limerick (Gowen 1988, 26-43; Gowen and Tarbett 1988; 1989; 1990), Caherdrinny, County Cork (Bower *et al.* 2011), Caherabbey Upper, County Tipperary (Molloy 2007a; 2009; Halwas 2007; Grogan and Roche 2007) and Newrath, County Kilkenny (Wren 2006c; Wren and Price 2011) as well as the court tomb at Ballynamona Lower, County Waterford (Powell 1938; Moore 1999, 1-2) and the portal tomb at Killaclohane, County Kerry (Connolly 2015). This would suggest that pottery was in use in both the everyday and for ritual activity. The introduction of agriculture brought new foodstuffs and pottery, which both enabled and was inspired by new cooking methods. Pot use would therefore, have been concerned with the preparation, storing and serving of food (Müller and Peterson 2015). Residue analysis of Early Neolithic pottery would suggest that most were used for cooking of foodstuffs, in particular dairy products (Smyth and Evershed 2015a; 2015b).

Image Redacted, See Waddell (2010, 51)

Figure 3.3 Early Neolithic Carinated Ware (Waddell 2010, 51)

Diet and subsistence.

In addition to the introduction of ceramics and new styles of stone tools, the Early Neolithic witnessed the arrival of a wide range of new foodstuffs and a new process of food procurement. The adoption of agriculture in Ireland is certainly one of the most important changes in the Neolithic and was regarded as the defining aspect for many years (eg. Piggott 1954; Case 1969). At the start of the Neolithic four new domesticated species, cattle, sheep, goats and pigs, were introduced into Ireland. Of these, only one wild equivalent, the wild boar, had been present in the preceding Mesolithic period (Woodman 2015, 26). It is clear then that cattle were not domesticated in Ireland but were domesticated elsewhere and introduced at the start of the Neolithic (Bollongino and Burger 2007; Tresset and Vigne 2007), either by contact and exchange networks with Neolithic communities or by Neolithic colonists from continental Europe. There is a possibility that pigs may have been domesticated locally (Cummings 2017, 68), while sheep and goats were domesticated in the Near East and introduced into Europe (Pedrosa *et al.* 2005).

The widespread adoption of domesticates was concomitant with a reduction in the reliance of wild animals and aquatic resources for sustenance. Although the amount of animal bone recovered from excavations is low, evidence for the presence of cattle, sheep or goat and pigs is recorded at Lough Gur, County Limerick (Cleary 2018), Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005) and Tankardstown, County Limerick (Gowen 1988, 26-43; Gowen and Tarbett 1988; 1989; 1990), while cattle are also recorded at Newtown (Carrigdirty Rock), County Limerick (O'Sullivan 2001, 73-86; Woodman 2016, 16). This is, however, likely to be an under-representative sample of the proliferation of domesticates in the Early Neolithic period due to the poor rate of preservation at numerous sites, such as Caherdrinny, County Cork (Bower *et al.* 2011), where identification of remains to taxonomic level was not possible.

The presence of domesticated animals can be detected not only in animal bones, but also in the dietary signature through isotopic analysis of human bone. Isotopic analysis shows an almost complete switch from a marine-based diet in the Mesolithic to one in which protein was obtained almost entirely from terrestrial resources (Schulting 1998; Schulting *et al.* 2012; Smyth and Evershed 2015b). A similar abrupt shift in diet at the start of the Neolithic is noted from Scotland, many parts of England, Brittany and Denmark (Tresset 2000, 18; Richards 2003; Hamilton and Hedges 2011). However, it should be noted that the remains of Neolithic fish baskets at Newtown (Carrigdirty Rock), County Limerick (O'Sullivan 2001, 73-86), would infer that riverine resources continued to played some part in subsistence practices during the period.

While the adoption of domesticates would clearly have provide meat for sustenance during the Early Neolithic, sheep, goats and cattle would also have produced milk. The analysis of fatty acid residues (lipids) on Early Neolithic ceramics have shown that virtually all have dairy lipids present (Smyth and Evershed 2015a; 2015b). This shows that milk or milk-derived products such as cheese, butter or yogurt were important to Neolithic foodways. The attractiveness of this new form of food may have also increased the desirability of these new animals and the availability of dairy products may have been one of the primary factors in the adoption of domesticated animals (Cummings 2017, 75).

At present there is only limited evidence for the use of wild animals for meat during the Neolithic in Ireland (McCormack 2007; Schulting 2013), with wild animals accounting for only 5% of faunal remains at British sites (Serjeantson 2011, 33). It would appear that red deer was introduced into Ireland early in the Neolithic (Woodman and McCarthy 2003), but whether this relates to hunting is less certain. The possibility exists that red deer was significant to the Neolithic belief system, with a strong presence of mushroom-headed pins made from deer antler in Neolithic passage tombs (Woodman and McCarthy 2003, 37), while a fragment of red deer antler is also found in association with burials at Annagh Cave, County Limerick (Ó Floinn 1992; 2011; Dowd 2008; Ó Donnabháin 2011). The introduction of red deer at the start of the Neolithic may therefore relate to ritual rather than economic practices. However, evidence from a number of sites may indicates that wild animals may have been hunted. Lough Gur, County Limerick (Cleary 2018) produced bones from barnacle geese and mallard, while hare and three fragments of small perching birds in addition to numerous unidentifiable mammal bones were identified at Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005). These may indicate that wild faunal resources were presumably caught when the opportunity arose and consumed when necessary.

Alongside domesticated animals the Neolithic also witnessed the introduction of cereals into Ireland. In similarity with the adoption of domesticates, the knowledge of how to grow and process cereals, in addition to the seeds themselves must have arrived from outside Ireland. The main crops in the Irish Neolithic would have been emmer wheat, barley (naked and hulled), as well as occasional evidence for einkorn wheat and naked wheat (McClatchie *et al.* 2014, 213). Other domesticated crops which were present in continental Europe, such as pea, lintel and chickpea, were absent (McClatchie *et al.* 2014, 210) possibly due to climate limitations. The presence of a high number of emmer wheat is noted at Tankardstown, County Limerick (Gowen 1988, 26-43; Gowen and Tarbett 1988; 1989; 1990) Caherabbey Upper, County Tipperary (Molloy 2007a; 2009; Grogan and Roche 2007; Halwas 2007) and Shanagh, County Cork (Ruttle 2013), while barley is noted at a number of house sites such as Gortore, County Cork (O'Donoghue 2006; O'Donoghue and Johnston 2013), Granny, County Kilkenny (Hughes 2006) and Newrath, County Kilkenny (Wren 2006c; Wren and Price 2011).

The cultivation of flax in the Early Neolithic is suggested from its identification at Danganbeg, County Kilkenny (Hull 2015, 96) and Clowanstown, County Meath (Mossop and Mossop 2009), the latter of which was radiocarbon dated to the Early Neolithic period and establishes flax amongst the earliest crops cultivated in Ireland (McClatchie *et al.* 2014, 210). The possibility that spelt wheat was present in the Neolithic is tentatively suggested from the assemblages from Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005) and Shanagh, County Cork (Ruttle 2013). However, this could not be substantiated since no diagnostic chaff remains were recorded, and the earliest reliable evidence for spelt wheat in Ireland is therefore in the Late Bronze Age (Monk 1986, 32).

Whether oats was cultivated in the Early Neolithic is difficult to ascertain as despite its occurrence in the assemblages from Kilkeasy (Monteith 2009; 2010) and Danganbeg, County Kilkenny (Hull 2015, 96), Caherdrinny, County Cork (Bower *et al.* 2011) and Caherabbey Upper, County Tipperary (Molloy 2007a; 2009; Grogan and Roche 2007; Halwas 2007), these were difficult to identify to species. It is possible that this material is instead wild oat (*Avena fatua*), which was once a weed of cultivation and commonly recorded in Neolithic archaeobotanical assemblages (McClatchie *et al.* 2014, 209).

An interesting observation is the lack of any chaff fragments from many Neolithic assemblage. Emmer is a glume wheat-type, which has tight fitting chaff and would require more processing prior to consumption (Renfrew 1973). The assemblage at Kilkeasy (Monteith 2009; 2010) and Danganbeg, County Kilkenny (Hull 2015, 96), Ballinglanna North, County Cork (Johnston and Tierney 2010) and Caherabbey Upper, County Tipperary (Molloy 2007a; 2009; Grogan and Roche 2007; Halwas 2007) produced evidence for chaff was therefore indicate that threshing had taken place on site. The lack of chaff at the majority of sites may suggest that this activity was occurring elsewhere, and the cereals were being consumed or stored on site. It is also probably that chaff was an important by-product of cereal cultivation, perhaps used as fodder for domestic animals (McClatchie *et al.* 2014, 212).

Early Neolithic farmers in Ireland do not appear to have engaged in shifting cultivation, but rather created a sense of place by practicing longer-term, fixed-plot agriculture (Whitehouse *et al.* 2014, 198) as plants associated with disturbed ground dominate the arable weed assemblages, and annuals are common. This suggests that early farmers were carrying out more intensive agricultural practices, the management of which may have included manuring to maintain fertility (Bogaard *et al.* 2007; Fraser *et al.* 2011). The construction of walled fields, such as the Céide Fields, County Mayo (Caulfield 1978; 1988) and Cool West, County Kerry (Mitchell 1989), may have been important in this type of agriculture, although the evidence for cereal cultivation is not readily apparent

(Coxon 1985; Molloy and O'Connell 1995a) and serious questions exist as to the supposed Neolithic origins of both landscapes (Whitefield 2017; see **Chapter 4**) .

While it appears that people in the Early Neolithic utilised little wild meat, the use of edible wild flora certainly continued. Hazelnuts are ubiquitous at Early Neolithic sites, as these preserve well in the archaeological record. Other plant remains which have also been identified in the archaeobotanical assemblage of the Neolithic include apple/pear from Tankardstown, County Limerick (Gowen 1988, 26-43; Gowen and Tarbett 1988; 1989; 1990), Caherdrinny (Bower *et al.* 2011), Gortore (O'Donoghue 2006; O'Donoghue and Johnston 2013), and Pepperhill, County Cork (Gowen 1988, 44-51) and blackthorn/sloes from Newrath, County Kilkenny (Wren 2006c; Wren and Price 2011), while raspberry/blackberry have been recovered at Caherdrinny, County Cork (Bower *et al.* 2011) and Caherabbey Lower, County Tipperary (McQuade 2007a) and would likely have supplemented cereal consumption on a seasonal basis (Zvelebil 1994).

The shift from hunter-gatherer to agriculturalist in the Early Neolithic marks a major change in subsistence strategies, which at initial glance may appear to be much more reliable. However, the switch from hunting and gathering to farming would have constituted a certain degree of risk, the more specific range of food available to Neolithic agriculturalists would have meant fewer alternatives if crop failure was to occur. The reliance on a limited range of cereals and produce from domesticated animals would have been far more specialised than the varied diet of preceding Mesolithic populations and would therefore have left Neolithic communities more susceptible to periods of food scarcity. This may account for the occasional use of wild faunal resources exhibited at certain Neolithic sites and the continued utilisation of edible, non-cultivated floral resources.

Settlement.

The previous two sections have outlined the range of activities associated with the introduction of a new lifestyle at the start of the Neolithic. These new activities, especially the adoption of fixed plot, cereal cultivation and animal husbandry probably created a specific sense of place in the landscape (Carlin and Cooney 2017, 27). This new sense of place or ‘ownership’ is most pronounced in the monumentality of the Early Neolithic in Ireland, which in this instance refers not only to the erection of enduring stone monuments or ‘houses of the dead’, (Smyth 2011, 13) but also the rectangular timber houses or ‘houses of the living’.

There are currently an estimated 90 Irish Neolithic houses from 54 sites across the island (Smyth 2014, 21), with 16 of these, from 11 sites, in the south of Ireland. They have been firmly dated within a very narrow time frame of just over 100 years (McSparron 2008; Cooney *et al.* 2011, 598; McLaughlin *et al.* 2016, 125; **Chapter** 4), which would suggest their use was limited to the first few generations after the start of the Neolithic. As has been discussed in detail elsewhere (Cooney 2000; Grogan 1996; 2002; Smyth 2006; 2007; 2011; 2013; 2014) most houses are approximately 6 – 12m by 4 – 8m in dimension. They are rectangular in plan, although some smaller examples are almost square, and a minor percentage have curved end walls. Walls were constructed using split oak planks and posts, post and wattle or a combination of both set into slot trenches. The majority of buildings contain rows or pairs of internal postholes, often arranged across the centre of the structure which frequently align with postholes within or just outside the slot trench. Some structures produced evidence of internal divisions with occasional internal walls defined by a slot trench running across the building. The deep foundations trenches and substantial postholes from numerous sites suggest that at some of these structures supported large and heavy roofs (Smyth 2014, 27-41).

Taphonomic processes, site truncation and the relatively short occupation phase (see **Chapter 4**) have left little evidence of the build-up of occupation levels, internal floors rarely survive, being truncated by later agricultural practices or topsoil stripping during excavation. Houses provided a setting for domestic activity, demonstrated by the recovery of pottery fragments, stone-working debris and food waste, as well as evidence for crop and animal husbandry recovered from most sites. Internal divisions and the presence of one larger, sometimes central ‘room’ in addition to one or more smaller rooms within certain houses suggest that different activities were carried out in different areas of the structure (*ibid.*, 51-55). The concentrations of artefacts found close to the entrances of some houses, such as Cloghers, County Kerry (Kiely 1999; 2003; Kiely and Dunne 2005) may suggest the specific use of this area for stone-working and other light-dependent activities.

On current distribution maps, there appears to be an overwhelming preference for constructing houses along river valleys and the mouths of major waterways. However, the distribution evidence is biased due to the fact that site location was determined by infrastructural development. At a site level structures tend to be located on gently sloping ground, which is frequently, though not always south or south-east facing (*ibid.*, 23-27). A pattern of two or three buildings clustered together, one or two similar sized structures with a third, often smaller structure located a short distance away, has emerged in recent years (Cooney 2000; Grogan 1996; Smyth 2014). This trend of multiple closely located structures is evident at Ballinglanna North, (Johnston and Tierney 2010), Caherdrinny (Bower *et al.* 2011), and Gortore 1, County Cork (O'Donoghue 2006; 2011), Tankardstown South, County Limerick (Gowen 1988; Gowen and Tarbett 1988; 1989; 1990), Granny, (Hughes 2006), and Earlsrath, County Kilkenny (McKinstry 2010b), where two structures were identified at each site. There are also examples that were constructed over previous activity (Smyth 2014, 22), such as at Granny (Hughes 2006, 7), where a number of post-holes appear to pre-date house construction.

The Early Neolithic timber house represents a distinct and novel form of settlement (Smyth 2014, 23), the homogeneity of which indicates that they 'represent a distinctive form of cultural and material engagement' at the start of the Neolithic (Carlin and Cooney 2017). The timber houses signify the connection between the introduction of agriculture and the adoption of sedentism (Smyth 2011). They represent a practical need for groups to remain together for a prolonged period to cultivate, harvest and process grain, while at the same time providing a symbolic focus for kin-based societies who wished to emphasis and pass on their separate rights and identities (*ibid.*, 2). The timber house, it has been argued, may have been a material expression of the seismic change which was occurring at the start of the Neolithic (Smyth 2014, 41), and represented the architectural manifestation of the adoption of a fully-fledged agricultural, Neolithic way of life (Thomas 2013, 290).

While timber house construction and intensive cultivation of cereals implies that a permanent settlement site was likely, animal rearing could have involved a seasonal movement to make use of the maximum amount of pasture, i.e. transhumance, or booleying. People may have been moving around with herds to utilise different pastures on a seasonal basis (Cummings 2017, 84), while the presence of wild edible flora may indicate a degree of 'gathering' and mobility still persisted. Garden plot need not be tended constantly but would draw people back to specific places on a cyclical basis. Neolithic settlement patterns may represent a form of 'tethered mobility' (Whittle 1997), where people were attached to a particular landscape but had a degree of mobility within it. Examples of temporary encampments like those at Caherabbey Upper, County Tipperary (Molloy 2007a; 2009; Grogan and Roche 2007; Halwas 2007), Manor East, County Kerry (Clarke 2012) or Ballinaspig More, County Cork (Danaher and Cagney 2004b; Hanley and Hurley 2013) and have been used by some communities engaged in transhumance or food gathering, or specialised activities such as the procurement of raw materials for craftwork.

Pit features are an additional source of evidence about Neolithic settlement regularly identified during excavations. Pit digging appears to have been a common practices throughout the Neolithic where material accumulated from occupation was deposited (Smyth 2012). Most pits contain the remnants of everyday occupation debris such as knapping debitage, pot sherds, hearth sweepings and plant remains (Cummings 2017, 85). Animal bones do not appear to have been regularly deposited, but this may relate to soil acidity and taphonomic factors rather than a deliberate depositional practice (Smyth 2012, 17). Early Neolithic pits are found in association with house sites, either inside the structure or in the immediate vicinity, on sites with more ephemeral structural evidence or in isolation, as pit clusters or as single pits (*ibid.*, 17). These 'isolated' examples are often identified on similar terrain as the house sites and may represent the final visible remnants of temporary settlements (Pollard 2001, 316), However, these pits should not necessarily be regarded as the casual discarding of rubbish and may instead represent separate acts of deposition in the landscape (Smyth 2012, 17), with material deposition a careful and considered act which took place at appropriate times (Thomas 2012, 5).

Monumentality and funerary tradition.

This section examines the diverse range of mortuary practices and monumentality documented in southern Ireland in the Early Neolithic. The construction of megalithic tombs in that period was a common thread running through many areas in north-western Europe and the most likely area from which the inspiration for monumental construction came to Britain and Ireland is northern France (cf. Sheridan 2010), where a monumental tradition was firmly established from the fifth millennium cal BC (Laporte *et al.* 2001; Scarre 2011). The limited amount of human remains associated with megalithic monuments suggest that people underwent a complex burial rite, possibly involving defleshing (Cummings 2017, 89). The bones were then deposited in a variety of ways, both within constructed stone monuments or in natural caves. However, the small number of human remains which have been recorded would indicate that the majority of people who died in the Early Neolithic would not have been deposited in these contexts.

A variety of monument types are exhibited in the Neolithic across Ireland, with significant regional differences demonstrated across the island. The separation of the Irish megaliths into four distinct classes by De Valera and Ó Nualláin (1961) continues to be the generally accepted model. Of these, wedge tombs date to the Chalcolithic/Bronze Age (O'Brien 1999) and passage tombs generally date to later in the Neolithic (Cooney *et al.* 2011, 637-657), although evidence of an earlier passage tomb tradition exists (Bergh and Hensey 2013; Schulting *et al.* 2017). Therefore, this section deals almost exclusively with Early Neolithic portal tombs, court tombs and cave burials, as these represent earliest form of monumentality and funerary identified in the region.

Portal tombs are commonest in Ulster, the south Dublin mountains and the south-eastern part of Ireland (Waddell 2010, 98), in addition to three examples in the south-west (see Appendix B). While portal tombs are a structure of simple plan, some of these monuments are outstanding examples of megalithic engineering. The construction usually consists of a single sub-rectangular chamber with the entrance flanked by a pair of large portal stones (*ibid.*, 97). A single capstone covers the tomb, and based on limited evidence, the cairns are of elongated, sub-rectangular form, though short oval and round cairns exist (Ó Nualláin 1983; Kytmannow 2008; Mercer 2014).

Relatively few of these megalithic monuments have been excavated, but one such example is at Poulnabrone in the Burren, County Clare (Lynch 1988; 1994; 2014; Lynch and Ó Donnabháin 1994). Excavation of the chamber revealed unburnt human bones representing at least 22 individuals, bones of various animals and diagnostically Early Neolithic artefacts including a triangular bone pendant, a piece of a mushroom-headed bone pin, a polished stone axe, two stone beads, several flint and chert implements and sherds of pottery commonly classified as Carinated Ware, which is recorded in the earliest Neolithic contexts in Ireland (Brindley 2011, 127-129). Similarly, the recent excavation of a portal tomb in Killacholane, near Castlemaine, County Kerry (Connolly 2015) revealed the remains of two individuals, in addition to sherds of Neolithic pottery, flint arrowheads, scrapers and a flint projectile-head. Radiocarbon dates for the burials are pending but based on the artefactual assemblage, usage in the first half of the 4th millennium is suggested.

As very few Irish examples have been excavated and those that have demonstrate later reuse of the monuments, a definite chronology is difficult to ascertain. At present using archaeological material culture and radiocarbon dating methods (Kytmannow 2008; Schulting 2014) the construction of these monuments is estimated to have occurred in the Early Neolithic. Currently, radiocarbon dates are available from five portal tombs (Smith *et al.* 1971, 98; Kytmannow 2008; Schulting 2014, 111), with the report on the Killacholane excavation pending (Connolly 2015). However, the well documented phenomenon of reusing megalithic tombs resulted in Bronze Age dates being returned from three of these tombs. Radiocarbon dates from Ballynacloghy, County Galway (Kytmannow 2008, 101; Mercer 2014, 248; Schulting 2014, 111) suggest the earliest burial phase occurred between 3770-3380 cal BC (4835±59, *UB-6694*), however the taphonomic complexities of these monuments create difficulties in determining the relationship between a single date and the construction and use of the tomb (Cooney *et al.* 2011). Only one example, Poulnabrone, County Clare (Lynch 1988; 1994; 2014; Lynch and Ó Donnabháin 1994), provides sufficient evidence to assess the likely dates of construction and use of portal tombs in Ireland.

The Poulnabrone dating is the earliest currently available for a portal tomb (see below) and it is at present unknown whether other portal tombs were constructed in the same period, though the date from Ballynacloghy, County Galway (Kytmannow 2008, 101; Mercer 2014, 248; Schulting 2014, 111) suggests a similar Early Neolithic date for construction and use. The suggestion that they were constructed during Early Neolithic, *c.*3800 cal BC, is supported by the latest Bayesian study of Early Neolithic agriculture in Ireland which refers to the *'emerging consensus'* that they were early in the Neolithic (Whitehouse *et al.* 2014, 183). The artefactual assemblages of most excavated portal tombs suggests that these were constructed during the period 4000 – 3600 cal BC, so the possibility that they were all contemporary is quite tenable (Mercer 2014, 38). The morphology of portal tombs is so similar in basic design, and Poulnabrone is so typical in all its features, that this conveys the impression that they may be contemporaneous, but further excavation is essential before such a claim can be verified (Mercer 2014).

It is probable that portal tomb construction predated court tombs, but the deposits found in each monument type support a close contemporaneity of use (Schulting *et al.*

2012; Schulting 2014). The monuments occur close together throughout the northern half of the country and in County Clare, but court tombs are almost entirely absent from southern Ireland (Waddell 2010, 88), with only one example, Ballynamona Lower, County Waterford (Powell 1938; Moore 1999, 1-2) recorded. Court tombs are distinguished by their roofless, oval forecourt at the entrance. Large slabs of rock were used to make the walls and roof of the very basic burial chamber, normally located at one end of the cairn, which although usually blocked after use could be immediately accessed from the outside courtyard (Waddell 2010, 87-97). The entrance forecourt probably acted as a defined audience area intended for group participation, while the narrow entry to the burial chamber suggests access may have been restricted to selected individuals.

Caves also seem to have been used for mortuary practices in the Early Neolithic, with at least five individuals from Annagh Cave, County Limerick (Ó Floinn 1992; 2011; Dowd 2008; Ó Donnabháin 2011) and as many as 22 from Kilgreany Cave, County Waterford (Dowd 2008, 308). The lack of full skeletal remains indicates that the removal of some bones may have occurred (Cummings 2017, 92) or may represent token deposition where only particular bones were selected for deposition in the caves. However, at both Annagh and Kilgreany, inhumation burials have been discovered where individuals appear to have been placed directly on the cave floors, in some cases in the crouched position with no evidence of grave-cuts. To date, these represent the only occurrence of cave inhumations in Ireland (Dowd 2008, 309). However, it is quite likely that, at some sites, scatters of human bones may actually reflect burials that were later disturbed and dispersed.

In some instances, token deposits may reflect ancestor veneration, with bones of the dead being placed in caves which were associated with the earlier dead. For example, the Middle Neolithic human bone from Killuragh Cave, County Cork (Woodman 1997) may have been deposited in the knowledge that this was a place of Mesolithic ritual activity. The dates of Early Neolithic burials indicate that the funerary use of caves in Ireland co-existed with the use of court tombs and portal tombs (Brindley and Lanting 1989). This has led to suggestion that the use of caves and tombs may have been interchangeable (Cummings 2017, 92), and may have been incorporated into localised but distinctly Neolithic mortuary practice in areas without megalithic tombs.

3.5.4. Where did the Irish Neolithic come from?

Whether the Neolithic in Ireland began as a result of acculturation or colonisation, the practices associated with it must have originated from outside of Ireland. The defining features of the Neolithic, ceramics, timber houses etc., have no parallels in the proceeding Mesolithic period and indeed the cultivated flora and domesticated fauna of the period were absent from post-glacial Ireland. Therefore, regardless of the model of Neolithisation, the ideas or people, in addition to the 'tools' necessary to 'be Neolithic' arrived here from elsewhere. To explore where this point or points of origin was/were, it is first necessary to briefly examine the regional Neolithic of north-west Europe at the beginning of the fourth millennium cal BC.

The Neolithic had its origins in the Near East from around 10,000 cal BC, where various hunter-gatherer communities domesticated plants and animals which formed the basis of an agricultural way of life (Cummings 2017, 28-29). This new agricultural way of life then began to spread into the surrounding regions along with other elements of what would become the Neolithic 'package', such as pottery (Müller 2015). When the Neolithic reached central Europe, domesticates and pottery began to appear along with the construction of large timber houses (Whittle 1996), before the construction of monuments such as chamber tombs, long barrows and enclosures was added to the Neolithic repertoire by the time it reach north-west Europe in the fifth millennium cal BC. By the time the Neolithic arrived in north-west Europe it appears to have been adopted slightly differently in each region (e.g. Larsson 2007; Louwe Koojimans 2007; Cassen 2009; Scarre 2011; Thorpe 2015) and it is briefly worth outlining these differentiations before considering whether each could have been a potential point of origin for the Irish Neolithic. However, it must be stated that this was not necessarily the direct 'point of origin' of the Neolithic, which may have arrived in Ireland, through Britain (Whittle *et al.* 2011).

Two particular areas of north-west Europe are, by geographical proximity, the most likely source of Neolithic 'ideas' or 'colonists' arriving in Ireland after 4000 cal BC[2]. The first of these is the Atlantic coastline of north-west France, where the arrival of Neolithic practices occurs in the fifth millennium cal BC (Cummings 2017, 29). The

[2] Discounting the potential for an earlier Neolithic presence at Ferriter's Cove (Woodman *et al.*, 1999) and Magheraboy (Danaher, 2007)

'*Villeneuve-Saint-Germain*' Neolithic spread into Normandy, western Brittany and the Channel Islands between 5000 – 4700 cal BC (Scarre 2011, 46) and produced evidence for domesticates, pottery and the construction of trapezoidal houses (Cassen *et al.* 1998). At the same time the *Cardinal/Epicardinal* Neolithic was spreading north from the Paris Basin into Brittany, however, no evidence for house construction is associated with this form of the Neolithic (Scarre 2011, 53). Despite this spread of Neolithic practices into north-west France, groups of hunter-gatherers would seem to have continued to exist along the Brittany coast (*ibid.*, 67) until 4800/4700 cal BC, when a switch to Neolithic agriculture occurs. Finally, the construction of large stone monuments, menhirs (Whittle 2000) and chambered passage tombs began in western Brittany, coastal Normandy and the Nord-Pas-de-Calais regions in the fifth millennium cal BC.

The sequence the arrival of Neolithic practices is very much different in the second potential 'point of origin' of the Irish Neolithic, Belgium and the Netherlands. In the southern part of the region, *Bandkeramik* Neolithic communities had arrived prior to the fifth millennium cal BC, which probably resulted in interactions with Mesolithic groups to the north (Cummings 2017, 32) and may have led to the adoption of certain elements of the hunter-gatherer lifestyle by these agriculturalists and *vice versa* (Louwe Koojimans 2007, 219; Thorpe 2015). These Neolithic groups, known as *Rössen/Blicquy* (Louwe Koojimans 2007) practiced agriculture, used pottery and constructed substantial timber houses (Crombé and Vanmortfort 2007), while evidence for domesticates began to appear in Mesolithic contexts. This may indicate that the hunter-gatherer, *Swifterbant,* communities began to incorporate selected facets of the Neolithic 'package' or alternatively these represented joints of meat obtained through exchange networks with Neolithic groups to the south (Louwe Koojimans 2007, 297). From *c.*4300 cal BC, however, the *Michelsberg* Neolithic emerged and both groups become more dispersed within the landscape, possibly adopting mobile pastoral practices supplemented by hunting, in addition to the construction large ditched enclosures, likely to have been centralised ceremonial centres (Crombé and Vanmortfort 2007). It is not until almost a millennium later that a fully sedentary, agricultural way of life is adopted in the region.

In this brief outline of the start and spread of the Neolithic into north-west Europe, it is apparent that a range of 'Neolithics' emerged in the latter centuries of the fifth millennium cal BC. All used pottery and most included the construction of some form of monumentality (Cummings 2017, 35). Certain groups incorporated aspects of farming with the previous Mesolithic lifestyle, while other practised agriculture almost exclusively. What is crucial is that none of the 'Neolithics' directly mirror the emerging Neolithic of the early fourth millennium in Ireland and substantial variations exist between the Irish Neolithic and those in north-west Europe. However, numerous advocates of the 'colonist' model have suggested a multi-point of origin as the cause for this lack of a direct parallel for the Irish Neolithic. Piggott (1954) argued that the Mesolithic/Neolithic transition was not a unitary process but that the Neolithic in Britain and Ireland consisted of several strands derived from different areas of continental Europe and arriving at different times for different reasons. While Case (1969, 181) suggested that the time and energies of the colonisers would have been concentrated initially on agriculture and not the construction of monuments, which explained the difference between the material in Neolithic Britain and Ireland and those in Brittany, northern France and Belgium, from where the colonists came. More recently Bradley (2008, 47) suggested that the regional variation resulted from Neolithic practices arriving from many different parts of Europe with their different Neolithic traditions.

This approach has been further championed by Alison Sheridan (2003a; 2004; 2010) who argues '*whether the observed patterning of these novelties constitutes one 'Neolithic' or several….these 'Neolithics' are viewed as in terms of various movements of incoming farming communities from the continent*' (Sheridan 2004, 9). As discussed above, Sheridan (2004; 2010) suggests the Neolithic in Britain and Ireland arrived through the migratory movements of various north-western European Neolithic communities. Following an initial 'failed' colonisation (Sheridan 2010, 91-92), an Atlantic 'Breton' strand envisages people from southern Brittany moving to the west coast of Britain and the north coast of Ireland and is characterised by the appearance of small megalithic closed chambers and small passage tombsalong the west coast of Wales, Scotland and the northern half of Ireland (Sheridan 2003a; 2003b; 2004; 2010). Sheridan (2010, 92) argues that the pottery from Achnacreebeag, western Scotland (Richie 1970) originates from the Breton late *Castellic Pinnacle* ceramic tradition in the Morbihan, while the questionable late 41st century cal BC date range for construction of the passage tomb at Carrowmore, Sligo (Burenhult 2001; Sheridan 2003b) is suggested as evidence for the arrival of the 'Breton' Neolithic in Ireland (Sheridan 2010, 95).

A second proposed point of origin for the Irish Neolithic is the 'Cross Channel-west' (Sheridan 2004, 10-12) or the 'Carinated Bowl Neolithic' (Sheridan 2010, 95-99), which suggest the origins of the Carinated Ware tradition and other aspects of the Neolithic package as being from the Nord-Pas de Calais region of northern France or the low countries. Sheridan (2010, 99) suggests similarities between the Carinated Ware pottery of Neolithic Ireland and the northern Chassey and early *Michelsberg* pottery, in addition to the leaf-shaped arrowheads (although not identical to Irish examples) of the latter, as evidence for a migratory movement of Neolithic colonists from these regions to Britain and Ireland. The final path represent the 'trans-Marche west' strand (*ibid.*, 99-100), which envisages migration from Normandy to south-west England, before spreading across Britain and Ireland, and is marked by the arrival of distinct pot styles and the presence of rotundae graves.

Image Redacted, See Sheridan (2010, 93)

Figure 3.4 Proposed 'points of origin' of the Irish Neolithic following Sheridan (2010, 93). (1) Initial 'failed' colonisation, (2) Atlantic Breton, (3) 'Carinated Bowl Neolithic'& (4) 'trans-Marche east'.

3.5.5. When did the Neolithic begin?

The question of when the Neolithic in southern Ireland began is one which will be considered in greater detail in the following chapter, however, this section provides a brief overview of the current understanding and suggestions for when Neolithic practices started to appear on the island. The seminal work which has addressed this question is the publication *Gathering Time* by Whittle *et al.* (2011). This multi-authored examination of the probable origin and dating of the various Neolithic indicators in Britain and Ireland has suggested two distinct models for the arrival of the Neolithic lifestyle in Ireland from Britain of between *3750 – 3680 cal BC* (Model 2, Cooney *et al.* 2011, 663) or *3815 – 3760 cal BC* (Model 3, *ibid.*, 663). These *posterior density estimate* date ranges are calculated by excluding the suggested construction date for Magheraboy (Danaher 2007, 112), in addition to the early cattle bones at Ferriter's Cove (Woodman *et al.* 1999) and by accepting the original interpretation of the dating at Poulnabrone, which placed the construction date in or after *3290 – 2520 cal BC* (Cooney *et al.* 2011, 604). This is based on the assumption that the human remains recovered from the cracks in the chamber floor were placed in the chamber shortly after construction before sediment had accumulated. If, however, this assumption was incorrect, and these remains were incorporated into the cracks in the limestone by later formation processes than a date for construction of *4270 – 3715 cal BC* was suggested (*ibid.*).

The accuracy of Cooney *et al.*'s (2011) Model 2 date range has more recently been corroborated by the Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016) which assessed the dating evidence for the introduction of agriculture to Ireland. This work suggests a '*rapid and abrupt transition to agriculture from c.3750 cal BC*' (Whitehouse *et al.* 2014, 1) but also note '*hints'* of earlier farming in a number of sites. This study proposes the occurrence of widescale intensive woodland clearance and the adoption of agriculture from *c.*3750 cal BC, a date which coincides with the 'house horizon', already identified (McSparron 2008; Cooney *et al.* 2011) and with the construction of court tombs (Schulting *et al.* 2012).

In recent years the causewayed enclosure at Magheraboy, County Sligo (Danaher 2007), which produced controversially early radiocarbon dates, has become central in discussions of the earliest evidence for the Neolithic in Ireland. Radiocarbon dates from carefully selected charcoal samples suggest a construction date of *4065-3945 cal BC* (Cooney *et al.* 2011, 584), although Whitehouse *et al.* (2014, 187) provide two additional dates from short-lived material which place the use and possibly construction of the site at post *c.*3750 cal BC. If the initial dates are correct, these would represent Neolithic activity much earlier than the models espoused by Cooney *et al.* (2011) and McLaughlin *et al.* (2016) and would have major implications for the understanding of when the Neolithic began in Ireland. However, as Whitehouse *et al.* (2014, 187) noted, the pre-3750 cal BC dates from Magheraboy are derived from charcoal and as such may potentially suffer from the 'old wood' effect, whereas the samples from short-lived material would correlate with the above models. If Magheraboy does represent a genuine presence of an early fourth millennium cal BC Neolithic community, it raises the question of why a similar Neolithic presence remains so unidentifiable elsewhere on the island (Carlin and Cooney 2017, 27).

However, while concerns exist about the early dates from Magheraboy, the early dating of human bone from Poulnabrone (Schulting 2014) provides robust evidence which questions the accuracy of Cooney *et al.*'s (2011) suggested start dates for the Neolithic in Ireland and is as Whitehouse *et al.* (2014, 17) suggests '*more difficult to discount*'. Lynch (2014, 194) describes a general '*impression of earliness*' of the Poulnabrone portal tomb and therefore suggests a Neolithic presence in the Burren, County Clare by *c.*3900 cal BC, or shortly after (*ibid.*, 175), and discusses the possibility that the Neolithic was adopted earlier in western Ireland than suggested by Cooney *et al.* (2011). The Bayesian models by Schulting (2014) which incorporate new radiocarbon dates from Poulnabrone with the earlier dates (Hedges *et al.* 1990) suggest a likely construction date of around 3900 – 3700 cal BC. Of the 5 proposed models, only models 3 – 5 are discussed here as models 1 and 2 include all determinations and may contain duplicates from the same individual, while models 3 – 5 include only those which are known to represent distinct individuals.

Model 3 included 16 determinations on distinct individuals, with Neolithic burial activity treated as a single phase, and suggested a start date of *3885 – 3720 cal BC.* Model 4, which proposed 2 phases of burial with 13 determinations on distinct individuals included in the initial phase, provided a date range of *3825 – 3710 cal BC* for the beginning of burial activity. Model 5, which included the radiocarbon dates from 1990 and 2012 and treated the burials as a single phase of activity, shows a date range of *3875 – 3725 cal BC* for the beginning of burial activity. All three models place the onset of deposition at Poulnabrone from *c.*3885 cal BC which would support the claim of portal tombs, or at least Poulnabrone being the earliest form of Neolithic megalithic monument in Ireland (ApSimon 1986; Whittle 2004). This would appear to suggest that they predate the construction of court tombs (Schulting *et al.* 2012) and the now well-defined 'house horizon' (McSparron 2008; Cooney *et al.* 2011; McLaughlin *et al.* 2016). However, a caveat must be placed on this as the relationship between the dates for human remains and construction of the tomb may not necessarily be linear. Older remains may have been incorporated into the tomb once constructed (Lynch and Ó Donnabháin 1994), as suggested by the uneven representation of the bone assemblage.

Model	Determinations included	Agreement	2δ Posterior Density Estimate (95.4%)	1δ Posterior Density Estimate (68.2%)
1	1990 dates only (n=9)	(A_{model}=96.1)	*4210 – 3700 cal BC*	*3995 – 3770 cal BC*
2	2012 dates only (n=20)	(A_{model}=111.2)	*3860 – 3720 cal BC*	*3810 – 3745 cal BC*
3	2012 dates only (n=16)	(A_{model}= 109.6)	*3885 – 3720 cal BC*	*3815 – 3750 cal BC*
4	2012 dates only, 2 phases (n=13)	(A_{model}=112.3)	*3825 – 3710 cal BC*	*3790 – 3730 cal BC*
5	1990 & 2012 dates (n=29)	(A_{model}=90.8)	*3875 – 3725 cal BC*	*3820 – 3755 cal BC*

Table 3.1 Bayesian models 1-5 for the start of burial activity at Poulnabrone (Schulting 2014, 100)

In this study an Early Neolithic date for construction of portal tombs is accepted as the models proposed by Cooney *et al.* (2011) were undertaken prior to the full publication of the site (Lynch 2014). If the models proposed by Schulting (2014) are correct then Poulnabrone can be said, with a degree of certainty, to be *'one of the earliest megalithic monuments in Ireland'* (Lynch 2014, 194). If the re-evaluated Poulnabrone dates (Schulting 2014, 108) and the early Magheraboy dates are included then the suggested 'arrival' of the Neolithic in Ireland may be substantially earlier. The early dates for domesticates from Ferriter's Cove, County Kerry (Woodman *et al.* 1999) and possibly also from Kilgreany Cave, County Waterford (Molleson 1985-6; Woodman *et al.* 1997; Dowd 2002) could potentially provide similar evidence for an earlier Neolithic presence than envisaged by Cooney *et al.* (2011). The implications of this will be addressed later in **Chapters 4** and **7**.

Chapter 4 - Dating the Early Neolithic in southern Ireland: The Archaeological Evidence.

4.1. Introduction.

While the previous chapter has outlined the archaeological evidence for the Early Neolithic in southern Ireland, this chapter explores the chronology of the Early Neolithic in greater detail. An overview of the chronology of the Early Neolithic is discussed, followed by a brief summary of sites within the region which can be dated, scientifically or through material culture associations to the Early Neolithic period. These sites were categorised into Early Neolithic I, II (cf. Whitehouse *et al.* 2014) and undated, with the primary focus on sites where a definitive chronology was available. This chapter then discusses the chronology of the Early Neolithic in more detail, primarily the Early Neolithic timber houses and sites closely associated with the diagnostic Carinated Ware tradition. Particular emphasis has been placed on the chronology of the occupation and use of these sites with Bayesian modelling used to provide a more refined date range for the introduction of Neolithic practices into the region.

4.2. Archaeological biases.

Archaeological research on the Neolithic in Ireland had traditionally tended to focus on megalithic monuments, the distribution of artefact finds, and excavation of major earthworks (e.g. Caulfield 1978; Eogan and Grogan 1991; Mallory 2011). Prior to the increase in development-led excavations from the mid-1990s, attempts to define the extent of Neolithic settlement in the landscape were relatively limited, depending upon research excavation and analysis of extant Neolithic megalithic sites. For these reasons, regions with an abundance of extant stone monuments were emphasised in studies of the Neolithic in Ireland. While the distribution of megaliths in various regions was used to indicate the presence of Neolithic settlement, an assumption appears to have existed that the absence of evidence of megalithic tombs in the southern region related to an absence of Neolithic people (McLaughlin *et al.* 2016, 120).

This assumption was challenged by the first major archaeological investigations associated with infrastructure projects in Ireland (Gowen 1988, 26-51) and as infrastructural development accelerated through the 1990s and 2000s (e.g. Kiely 1999;

Danaher 2003; O'Donoghue 2006; Hughes 2006; Bower *et al.* 2011; Ruttle 2013), extensive evidence for Neolithic settlement was identified across the region. However, these sites will inevitably be biased towards certain locations, as most identified Neolithic sites are as a result of developer-led excavations along major road and gas pipeline routes. Decisions made during post-excavation analysis also heavily influence the archaeological dataset. Ephemeral features generally offer less scope for interpretation than houses and consequently, with finite resources, commercial archaeologists have been somewhat reluctant to subject them to the degree of specialist analyses and radiocarbon dating, often exhibited in the analyses of other types of prehistoric sites (Smyth 2012, 13).

Neolithic houses are possibly over emphasized in the radiocarbon record as research interests have traditionally focused on substantial Neolithic structures as a means to better understanding the agricultural practices of the period. Ephemeral features such as pits and spreads have tended to be less subjected to robust chronological investigation with large numbers being dated to the Neolithic based on diagnostically Neolithic material culture without supporting radiocarbon dates. The fact that a large proportion of ephemeral Neolithic features, such as pits and post-holes, are undated on multi-period sites, is almost certainly an additional source of bias. An understated fact is that ephemeral pit and post-hole sites are found during development-led excavations far more frequently than any other type of Neolithic site, yet they are under-studied. Therefore, an important aspect of the settlement narrative of the Early Neolithic may be missing as a result (cf.Smyth 2012; McLaughlin *et al.* 2016, 140)

4.3. Chronology.

4.3.1. Introduction

Much recent research has made significant contributions to our understanding of the island's Neolithic archaeology (Smyth 2006; 2007; 2010; Bradley 2007; Whittle *et al.* 2011), whilst the application of large-scale archaeological dating programmes using Bayesian statistical modelling has provided much more refined chronologies for various Early Neolithic sites types and indeed the start of the Neolithic in Ireland (Bayliss *et al.* 2007; Whittle *et al.* 2011; McLaughlin *et al.* 2016). Several alternative models for the introduction of Neolithic practices have been proposed elsewhere (McSparron 2008;

Cooney *et al.* 2011; McClatchie *et al.* 2014), and these examine the chronology of various aspects of what defines the Early Neolithic.

McSparron (2008, 18) explored the chronology of Early Neolithic timber houses, applying what he termed 'gold standard' criteria for dating these monuments, relying on radiocarbon determinations form short-lived, single-entity material from secure contexts, to better define the chronology of occupation at Early Neolithic timber houses to between final quarter of the 38th century cal BC and the latter half of the 37th century cal BC. This 'house horizon' also coincides with the radiocarbon dating evidence for the introduction of cereals (McClatchie *et al.* 2014), suggesting that the late 38th and early 37th centuries cal BC were a period of intense activity in the Neolithic. This fits well with Cooney *et al.*'s (2011) re-evaluation for the appearance of the Neolithic in Ireland. Cooney *et al.* (2011) incorporated various aspects of the Early Neolithic to propose a date for the beginning of the Neolithic in Ireland (see below). Two probable models for this were outlined which dated the beginning of Neolithic practices to the latter half of the 38th century cal BC (Model 2) or to the end of the 39th or early 38th century cal BC (Model 3). Both models would seem to challenge the traditional date of *c.*4000 cal BC for the Mesolithic/Neolithic transition in Ireland.

4.3.2. Early Neolithic I *c.*4000 – 3750 cal BC.

The transition from Mesolithic hunter-gather to Neolithic agriculturalist in Ireland has traditionally been place at *c.*4000 cal BC, however this has tended to rely on a number of potentially anomalous charcoal dates and on the earliest date of 2 sigma, 95% probability, calibrated date ranges. A reappraisal of the radiocarbon record, which has focused on the use of short-lived material has refined the dating of the beginning of the Neolithic in Ireland to no earlier than 38th century cal BC (Cooney *et al.* 2011; McLaughlin *et al.* 2016). At Ferriter's Cove (Woodman *et al.* 1999), and more tentatively at Kilgreany Cave (Woodman *et al.* 1997), cattle bones dating to before 4000 cal BC hint that Neolithic pastoral farming had already become established in a way that is otherwise invisible archaeologically or alternatively that possible contact existed between Late Mesolithic communities in Ireland and Neolithic communities in Britain or continental Europe. Conversely, evidence for arable agriculture before *c.*3750 cal BC is lacking, aside from inconclusive palynological data (Behre 2007; Whitehouse *et al.* 2014). The best evidence for a Neolithic presence in Ireland before *c.*3750 cal BC is found in the burial record. The commencement of burial activity at Poulnabrone, County Clare, has been dated to the middle of the 39th century cal BC (Schulting 2014, 108), it is therefore possible that these people represented Ireland's earliest Neolithic communities whose settlements are yet to be discovered.

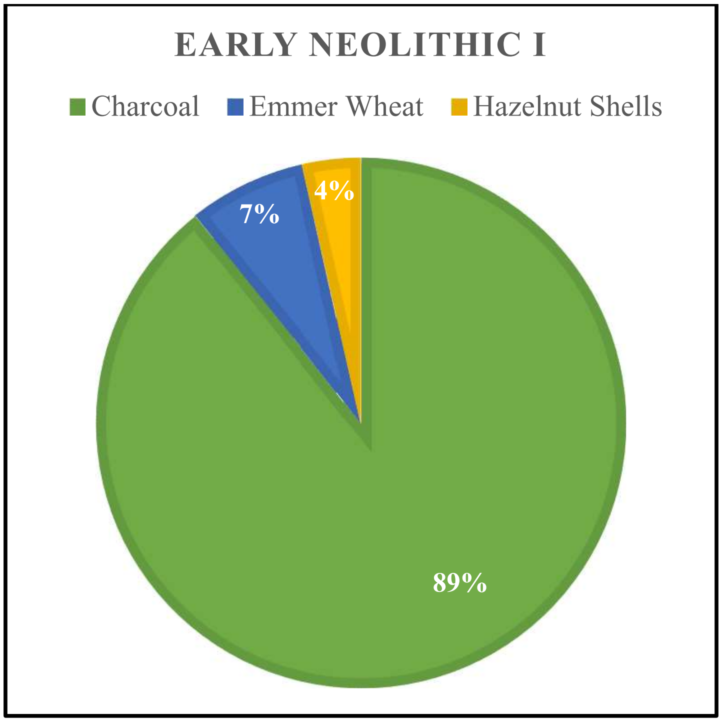

Figure 4.1 Material used for Early Neolithic I radiocarbon dates.

Twenty-eight radiocarbon dates from seventeen sites in southern Ireland have been calibrated to this Early Neolithic I phase. Careful evaluation of these archaeological dates suggests these should be treated with considerable caution as these determinations are largely based on radiocarbon dates derived from charcoal. Of the twenty-eight radiocarbon dates from this Early Neolithic I phase, the overwhelming majority, twenty-five, were obtained from charcoal deposits identified during excavation. The remaining three dates are obtained from short-lived organic material, two from charred emmer wheat grains (Tankardstown South *OxA-1476* and *UBA-14739*) and one from charred hazelnut shells (Scart *Poz-26554*).

A number of sites in the Early Neolithic I category that have early charcoal dates also produced dates from short-lived samples which placed them in a later period (e.g.

Early Neolithic II). Of the seventeen sites, which have produced charcoal radiocarbon dates from Early Neolithic I, nine have also produced dates from short-lived material to the later Early Neolithic phase II. As the dates from these nine sites were obtained from charcoal, predominantly oak, it is highly likely that these are the result of the 'old wood effect' and should be treated as *termini post quos* when dating these sites. The two dates from charred emmer wheat from Tankardstown South 1 (*OxA-1476* and *UBA-14739*) are the only dated cereal grains from the Early Neolithic I period, however, it should also be noted that the date ranges extend into Early Neolithic II and the application of Bayesian modelling (see Figure 4.16, Figure 4.18 and Appendix B-72) emphasises that activity at the sites in question commenced during this Early Neolithic II phase. Therefore, it can be reasonably stated that Early Neolithic I contains no unambiguous evidence for the presence of arable activity. In the absence of radiocarbon dates from other dated material from the remaining eight sites, charcoal dates were used to categorise these sites. However, the 'old-wood' effect likely pushes these sites, including a number of rectangular house sites [Barnagore (site 3) and Gortore (site 1)], into Early Neolithic I.

4.3.2. Early Neolithic II *c.*3750 – 3550 cal BC.

Early Neolithic II shows the region relatively richly populated (see Figure 4.3 & Figure 4.4) with sites, not just rectangular houses, but also ephemeral settlement sites and burials. Sites dating to the Early Neolithic II period, are discussed below in more detail. While the rectangular structures are all irrefutably Early Neolithic in date (McSparron 2008; Cooney *et al.* 2011; Whitehouse *et al.* 2014), considerable uncertainty surrounds the dating of many Early Neolithic ephemeral features, as the majority of these sites are dated only by radiocarbon determinations on charcoal samples, problematic due to potential 'old wood' effects. However, a number of these within the study area have produced evidence of settlement activity post-dating the 'house horizon' and are discussed in more detail below.

Twenty-eight sites within the region produced radiocarbon dates which fall between the date range *c.*3750 – 3550 cal BC. A total of eighty-five radiocarbon dates from the Early Neolithic II period were catalogued in the study area, most of which, for the reasons outlined above, are from the Neolithic timber houses of the region. Unlike the dates from the previous Early Neolithic I period most of these dates were obtained from short-lived organic material. Thirty-nine radiocarbon dates (46%) were obtained from charred wheat grains recovered during excavation, while a further thirteen (15%) were from charred hazelnut shells. Eleven radiocarbon dates (13%) were from human bone, two (2%) were from animal bone, three were obtained from waterlogged wood (4%) and the remaining seventeen (20%) dates were from charcoal.

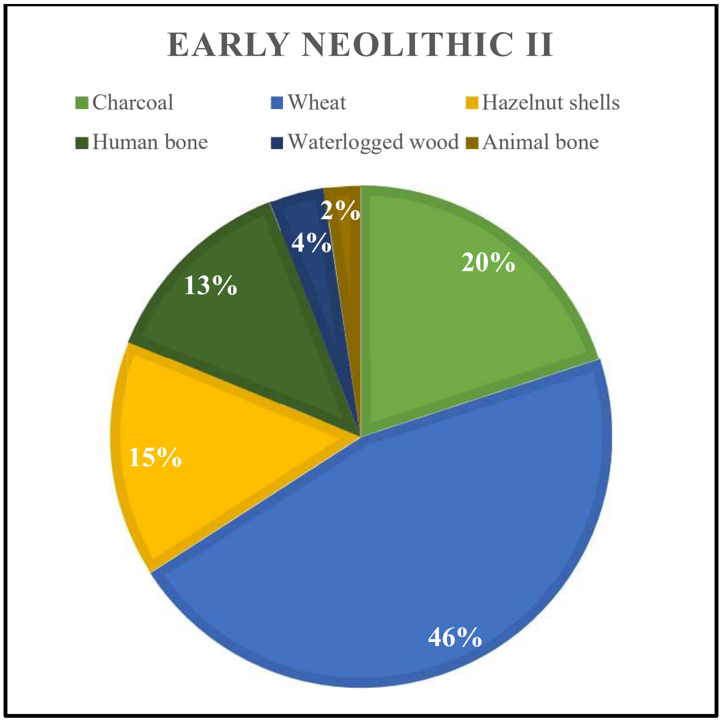

Figure 4.2 Material used for Early Neolithic II radiocarbon dates.

4.3.3. Undated, likely Early Neolithic.

Thirty-six sites were attributed to the Early Neolithic without radiocarbon dating, either by the identification of diagnostically Early Neolithic material culture (e.g. Carinated Ware) or in the case of portal and court tombs, on evidence from excavated examples outside the study area. Although it should be noted that neither type of monument has been as thoroughly excavated or dated as the settlements now are. The chronology of portal tombs is particularly uncertain, however, there is an emerging consensus that they fall comparatively early in the Neolithic (Kytmannow 2008; Schulting 2014). Court tomb construction began from *c.*3700 cal BC, and their use continued far longer than that of the rectangular houses (Schulting *et al.* 2012).

The archaeological evidence from southern Ireland indicates a total of sixty-eight sites which can be dated, either scientifically or diagnostically, to the Early Neolithic *c.*4000 – 3550 cal BC. The majority (50%) are assigned to the Early Neolithic as a result of the identification of diagnostic Early Neolithic material culture during excavation or from excavated parallels elsewhere. Eight sites (11%) are assigned to the Early Neolithic I phase based on radiocarbon dates obtained from charcoal. The remaining twenty-eight sites (39%) were assigned to the Early Neolithic II phase (*c.*3750 – 3550 cal BC) based on radiocarbon dating evidence, nine of which also returned dates from the Early Neolithic I phase (*c.*4000 – 3750 cal BC) probably as a result of the 'old wood' effect.

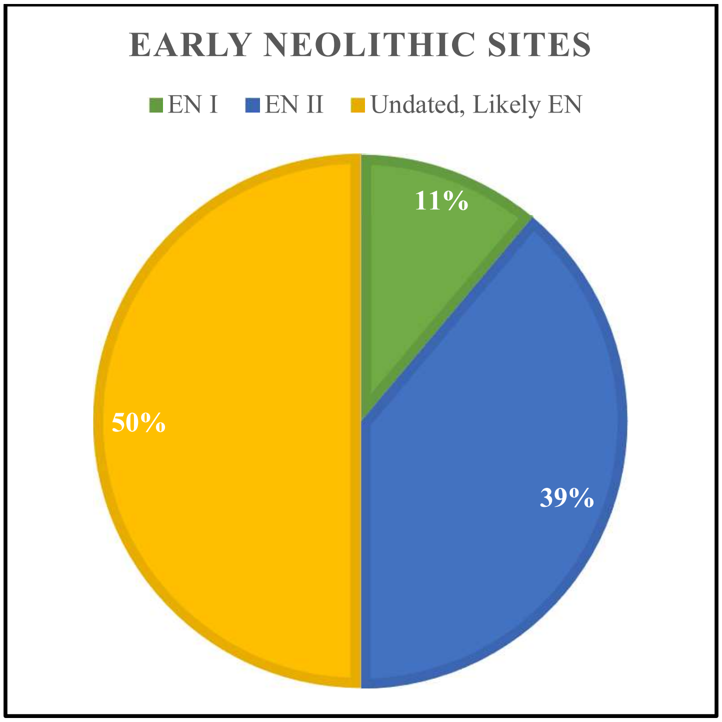

Figure 4.3 Percentage of sites assigned to each Early Neolithic phase.

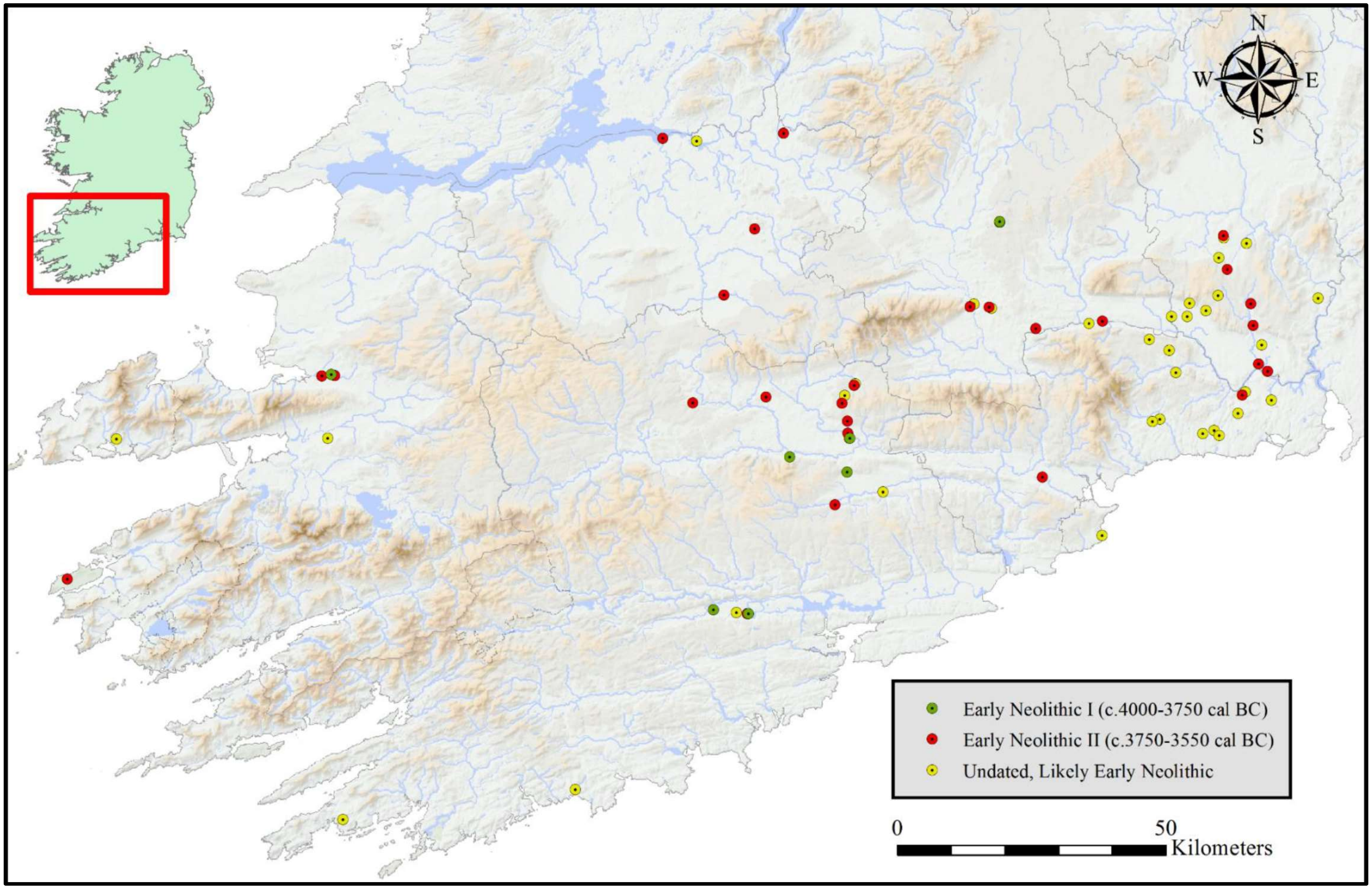

Figure 4.4 Early Neolithic sites in southern Ireland

4.4. The chronology of Early Neolithic in southern Ireland.

The primary focus of this chapter is to attempt to outline and refine the chronology of the earliest evidence for Neolithic practices, in particular settlement activity, in southern Ireland. To better investigate this, the following section details the specific archaeological evidence for the start of the Neolithic in southern Ireland. Two specific site types are emphasised, the Early Neolithic timber houses, the strongest unequivocal evidence for the commencement of Neolithic settlement, and the less well-defined pit, post-hole and stake-hole sites. For a more rigorous dataset to be established, only those ephemeral sites which produced Early Neolithic radiocarbon dates in addition to diagnostically Early Neolithic material culture are included.

4.4.1. Early Neolithic houses in southern Ireland.

Early Neolithic timber houses are the best dated of the Neolithic site types for various reasons discussed above. Especially visible during excavation and of considerable research interest, they have become the focus of extensive radiocarbon dating programmes. Many older excavations had tended to obtain radiocarbon dates from charred oak samples, the most prominent source of organic material during excavation. However, in recent years, studies of Early Neolithic houses have demonstrated greater appreciation of the 'old wood' effect and have placed greater emphasis on obtaining radiocarbon dates from single entity, short-lived material such as charred cereal grains and hazelnut shells (e.g. McSparron 2008; Cooney *et al.* 2011; Smyth 2014).

While the significance of Early Neolithic houses as a source of understanding of the chronology of the Early Neolithic in Ireland cannot be over-emphasised, these structures cannot be seen as belonging to the entirety of the Irish Early Neolithic, but a very tightly defined 'House Horizon' within it (Cooney 2000; McSparron 2008; Cooney *et al.* 2011; Smyth 2010; 2013; 2014). Recent Bayesian analysis of the radiocarbon record has revised and narrowed the appearance of the rectangular house, a distinct marker for the presence of Neolithic people, to the latter decades of the 38th century cal BC (McSparron 2008; Cooney *et al.* 2011; McLaughlin *et al.* 2016). The model proposed by Cooney *et al.* (2011) demonstrates that use of these monuments was relatively short, less than 120 years, possibly representing three or four generations in human terms. Given the *c.*1500-year span of the Neolithic in Ireland, the occupation period of Neolithic timber houses would appear to be stunningly short.

Similar modelling of short-lived material from Neolithic houses in southern Ireland was undertaken as part of this study to explore how the chronology of the southern group of houses fit with the model proposed by Cooney *et al.* (2011). In total, nineteen confirmed Early Neolithic rectangular houses from twelve sites have been identified. A further possible rectangular house at Shanagh (site 1) (Ruttle 2013) is also included in this study.

Ballinglanna North (site 3), County Cork.

Two structures were excavated in advance of road construction at Ballinglanna North, County Cork (Johnston and Tierney 2010). (For a full site description see Appendix B-8). Three Neolithic radiocarbon dates were obtained from the excavation at Ballinglanna North (site 3). However, only one of these was from short-lived material, *UB-14099* from the eastern foundation trench (C.109) of structure 1 was obtained from charred hazelnut shells. Two further radiocarbon determinations *UB-13145* and *UB-13146* were obtained from hazel charcoal. For the purposes of this study the two charcoal derived dates have been treated as *termini post quos* for occupation at the site.

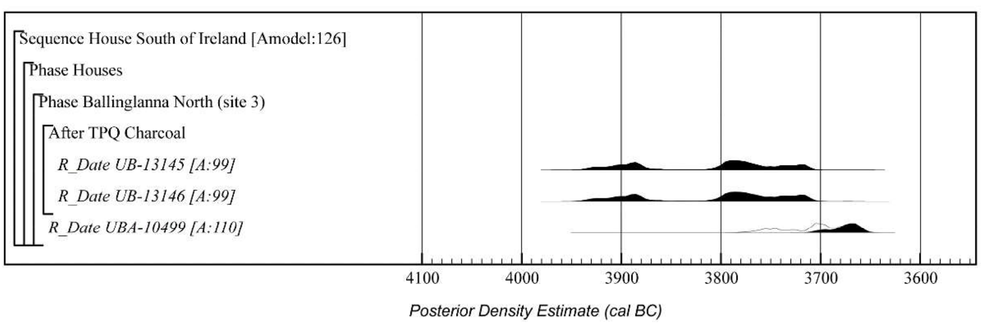

Figure 4.5 Bayesian modelled dates from Ballinglanna North (site 3), from the model shown in Figure 4.20

Barnagore (site 3), County Cork.

A rectangular house was excavated in advance of road construction at Barnagore, west of Cork City, County Cork (Danaher 2003). (For a full site description see Appendix B-18). Two Early Neolithic radiocarbon dates were obtained from the excavation at Barnagore (site 3). Both *UB-17411* from the east foundation trench (C.38) and *UB-17412* from the south foundation trench (C.83) were obtained from oak charcoal. For the purposes of this study the both charcoal derived dates have been treated as *termini post quos* for occupation at the site.

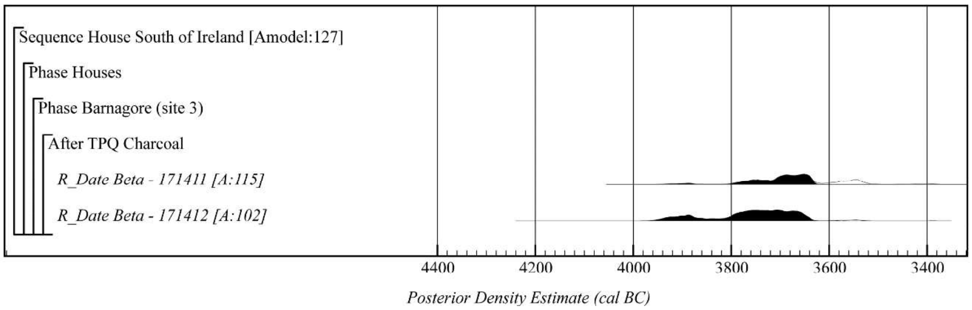

Figure 4.6 Bayesian modelled dates from Barnagore (site 3), from the model shown in Figure 4.20

Caherdrinny (site 3), County Cork.

Two structures were excavated in advance of road construction at Caherdrinny, County Cork (Bower *et al.* 2011). (For a full site description see Appendix B-23). Four Early Neolithic radiocarbon dates were obtained from the excavation at Caherdrinny (site 3), however none were from short-lived material. *UB-13284* from a hearth (C.973) in the interior of structure 1 was obtained from cherry wood charcoal, while *UB–13286*, was derived from hazel charcoal recovered from post-hole (C.877) in the outer wall of the structure. *UBA-13292* from hazel charcoal obtained from one of the posts (C.636) from structure 2, while *UBA-13289,* obtained from hazel charcoal, was identified from a hearth (C.294) south of structure 2. For the purposes of this study all four charcoal derived dates have been treated as *termini post quos* for occupation at the site.

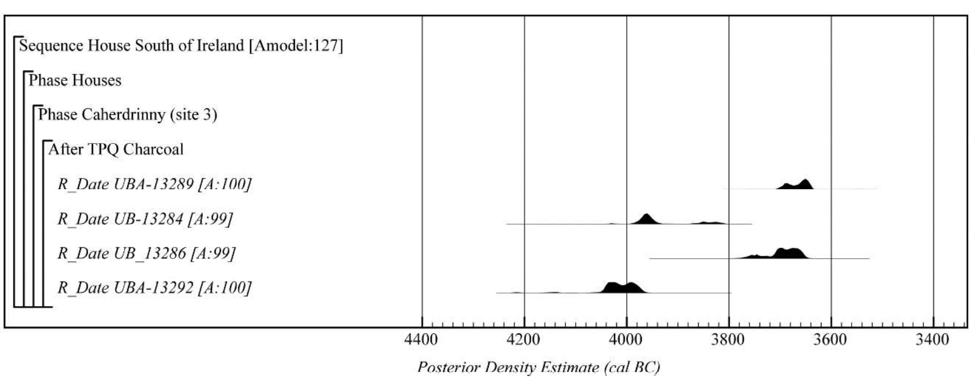

Figure 4.7 Bayesian modelled dates from Caherdrinny (site 3), from the model shown in Figure 4.20

Cloghers, County Kerry.

Excavation in advance of a housing development at Cloghers, County Kerry (Kiely 1999; 2003) uncovered the remains of a rectangular structure. (For a full site description see Appendix B-25). Two statistically consistent radiocarbon dates (T'=0.8; T'(5%)=3.8; v=1) (Ward and Wilson 1978) were obtained for the structure at Cloghers. *Beta-134226* and *Beta-134227*, both from charred hazelnut shells, have been treated as dating to the occupation phase at the site.

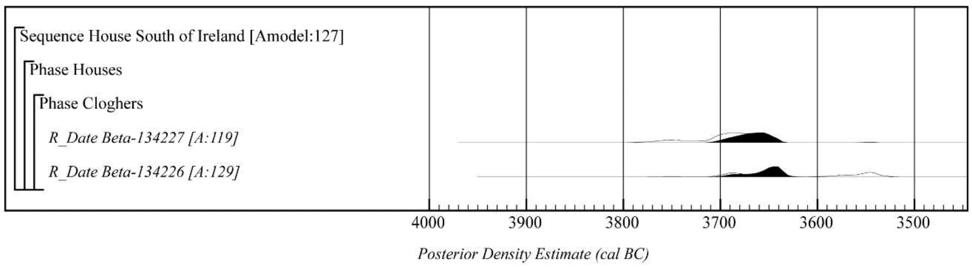

Figure 4.8 Bayesian modelled dates from Cloghers, from the model shown in Figure 4.20

Earlsrath (site AR031), County Kilkenny.

Two structures were excavated in advance of road construction at Earlsrath, County Kilkenny (McKinstry 2010a). (For a full site description see Appendix B-35). Five Early Neolithic radiocarbon dates were obtained from the excavation at Earlsrath (site AR013). Three were associated with structure 1, *UBA-14153* was obtained from oak charcoal recovered within the foundation trench (C.4) of structure 1, while *UBA-14155* from alder charcoal was recovered from post-hole C.45, also from structure 1. A third radiocarbon date *UBA-14158* was obtained from charred hazelnut shells found in post-hole (C.72) which was part of the entranceway for structure 1. Additionally, *UBA-14154* from pine charcoal was recovered from the north-western foundation trench (C.13) of structure 2. A second date *UBA-14160* from an interior feature (C.83) of structure 2 was obtained from hazel charcoal. A sample of hazelnut shell fragments from fill C.9 of foundation trench C.7 (structure 2) returned a date of 2620 – 2460 cal BC (4005±32, *UBA-14159*), this is however likely to be intrusive in the context. As only sample *UBA-14158* was obtained from short-lived material, it was the only date from Earlsrath (site AR031) included in the model. The others have been treated as *termini post quos* for occupation at the site.

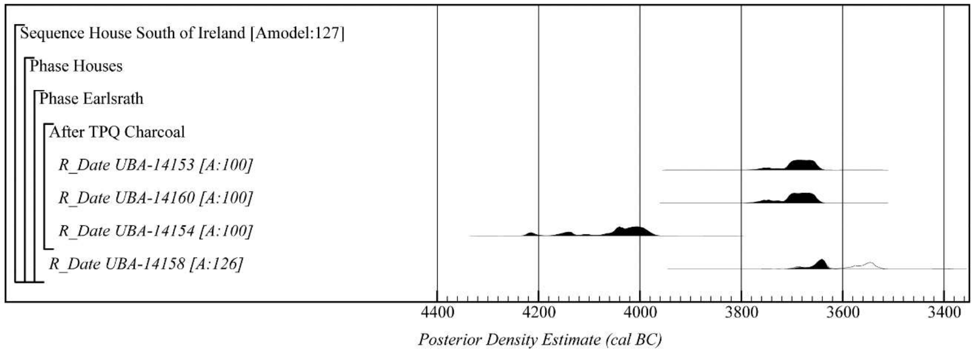

Figure 4.9 Bayesian modelled dates from Earlsrath (site AR035), from the model shown in Figure 4.20

Gortore (sites 1 & 1b), County Cork.

Two structures were excavated in advance of road construction at Gortore, County Cork (O'Donoghue 2006; O'Donoghue 2011). (For a full site description see Appendix B-40 & B-41). A single Early Neolithic radiocarbon date was obtained from the excavation at Gortore (site 1). This determination (*UB-6769*) is derived from charcoal recovered from foundation trench C.157 and can be treated as *terminus post quem* for occupation at the site.

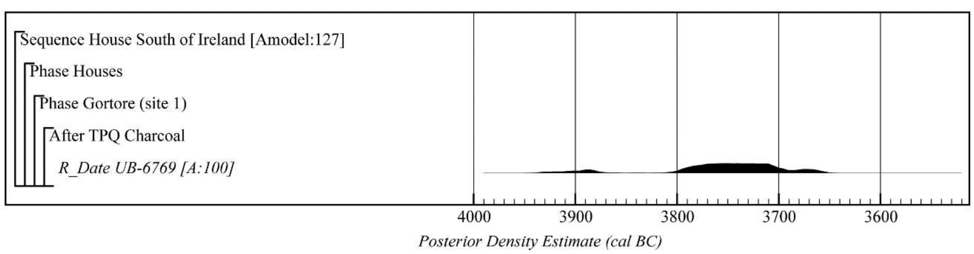

Figure 4.10 Bayesian modelled dates from Gortore (site 1), from the model shown in Figure 4.20

Granny (site 27), County Kilkenny.

Two structures were excavated in advance of road construction at Granny, County Kilkenny (Hughes 2006). (For a full site description see Appendix B-43). Four radiocarbon dates were initially obtained following excavation, of these only one was from short-lived material, *UB-6634* (hazelnut shell). Further radiocarbon dates were obtained for Granny (site 27) as part of the Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.*

2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Four radiocarbon dates, *UBA-14683, UBA-14684, UBA-14685, UBA-14686* were obtained from cereal grains identified in pit C.27322. These four dates, along with *UB-6634*, were included in the model as relating to Early Neolithic occupation at Granny (site 27). The remaining three radiocarbon determinations *UB-6633*, *UB-6635* and *UB-6*315 have been treated as *termini post quos* for occupation at the site.

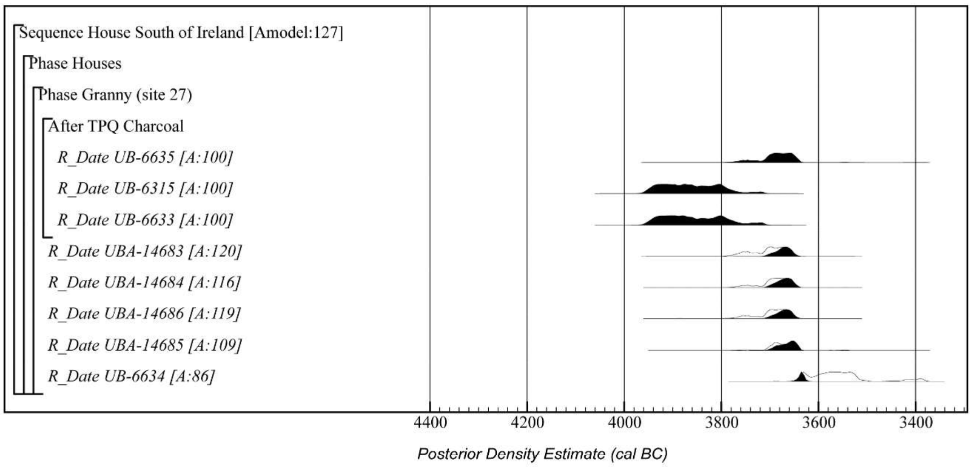

Figure 4.11 Bayesian modelled dates from Granny (site 27), from the model shown in Figure 4.20

Kilkeasy, County Kilkenny.

Excavation in advance of road construction at Kilkeasy, County Kilkenny (Monteith 2010) revealed the remains of foundation features associated with a possible small house structure. (For a full site description see Appendix B-48). Six Early Neolithic dates were returned from the structure and associated pits. Two statistically consistent radiocarbon dates, *Poz-25458* and *Poz-25458* (T'=0.1; T'(5%)=3.8; v=1) from pit C.29 (Ward and Wilson 1978) and two statistically consistent radiocarbon dates *Poz-25460* and *Poz-25475* (T'=2.3; T'(5%)=3.8; v=1) (*ibid.*) from slot trench C.5 were included in the Bayesian model for activity at Kilkeasy. *Poz-25461* and *Poz-25474* from hearth C.3 were shown to be statistically inconsistent (T'=16.5; T'(5%)=3.8; v=1) (*ibid.*), *Poz-25474* is likely to be a later intrusion and was therefore also excluded in the model. *UBA-10489* was obtained from hazel charcoal and has been treated as *terminus post quem* for activity at the site.

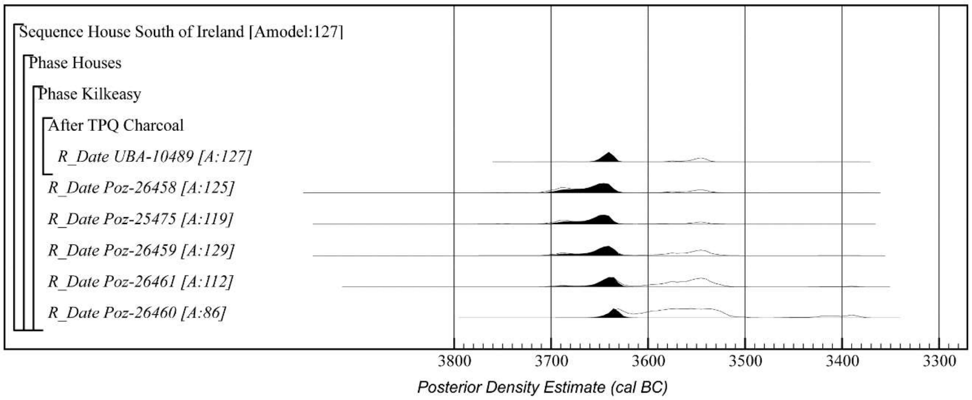

Figure 4.12 Bayesian modelled dates from Kilkeasy, from the model shown in Figure 4.20

Marlfield, County Tipperary.

A structure was uncovered during archaeological testing in advance of a proposed development at Marlfield, County Tipperary (Lennon 2007). (For a full site description see Appendix B-57). Two radiocarbon dates, *UBA-14792* and *UBA-14793,* were obtained from wheat grains recovered from fill, C.4 of the slot trench and have been treated as dating to the occupation phase at the site (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016).

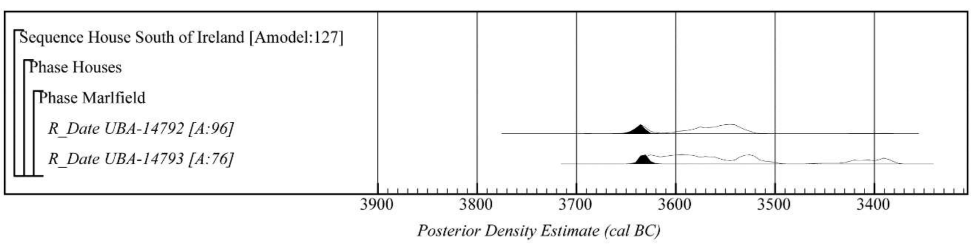

Figure 4.13 Bayesian modelled dates from Marlfield, from the model shown in Figure 4.20

Newrath (site 37), County Kilkenny.

Excavations in advance of road construction at Newrath, County Kilkenny (Wren 2006c) uncovered the remains of a rectangular structure. (For a full site description see Appendix B-63). A single radiocarbon date (5587±40, *UB-6642*) from charred hazelnut shells from the fill of the north-western slot trench produced a date range of 4500-4340 cal BC. On comparative grounds the Newrath house probably dates to the Early Neolithic and the hazelnut shells may have been residual in the context in which they were found, possibly resulting from Late Mesolithic activity in the vicinity and was therefore not included in the model.

Pepperhill, County Cork.

A probable but severely truncated rectangular structure was excavated at Pepperhill, County Cork (Gowen 1988) in advance of gas pipeline construction. (For a full site description see Appendix B-66). A single radiocarbon date *GrN-15476*, from oak charcoal, was obtained following excavation and has been treated as *terminus post quem* for occupation at the site. Four radiocarbon determinations *UB-14788, UB-14789, UB-14790* and *UB-14791* were later obtained from charred wheat grains and hazelnut shells recovered from post-holes C.2 and C.6 and have been treated as dating to the occupation phase at the site. (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016).

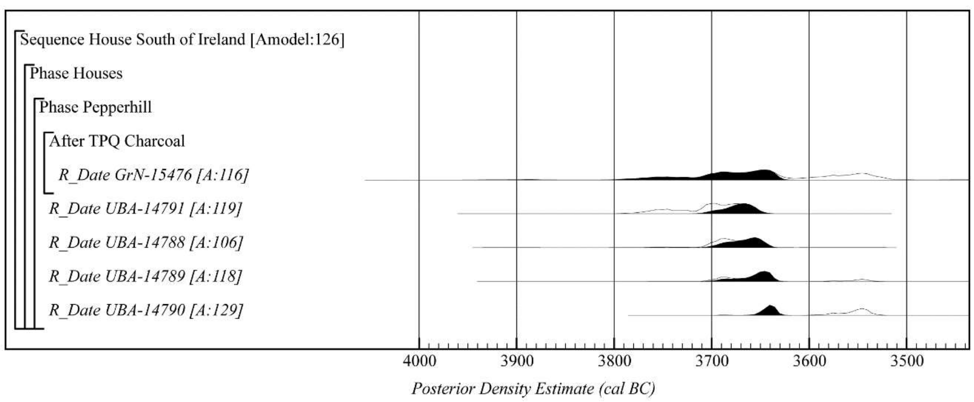

Figure 4.14 Bayesian modelled dates from Pepperhill, from the model shown in Figure 4.20

Shanagh (site 1), County Cork.

Features indicative of Early Neolithic settlement activity were excavated in advance of road construction at Shanagh, County Cork (Ruttle 2013). (For a full site description see Appendix B-69). Three radiocarbon dates, *UBA-21419* (cereal grain), *UBA-21417*, (hazelnut shell) and *UBA-21418* (hazelnut shell), were obtained from the features excavated at Shanagh (site 1). All three dates were treated as related to the Early Neolithic occupation at the site and were included in the model.

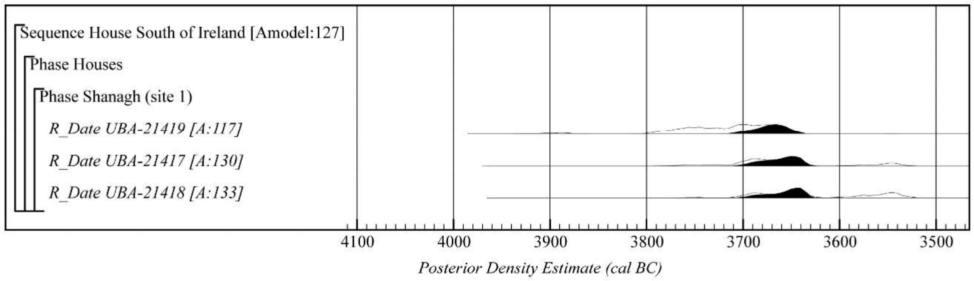

Figure 4.15 Bayesian modelled dates from Shanagh (site 1), from the model shown in Figure 4.20

Tankardstown South, County Limerick.

Two structures were excavated at Tankardstown South, County Limerick (Gowen 1988; Gowen and Tarbett 1988; 1989; 1990) in advance of gas pipeline construction. (For a full site description see Appendix B-72). Following the initial phases of excavation, seven radiocarbon dates were obtained for Tankardstown South. However, only two, *OxA1476* and *OxA-1477* were from short-lived material (emmer wheat grains). Ten additional radiocarbon dates, all obtained from wheat grains (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016), and the two original dates, *OxA1476* and *OxA-1477*, were deemed to relate to the Early Neolithic occupation at Tankardstown South. The remaining five dates, *GrN-14713, GrN-15386, GrN-15387, GrN-16557* and *GrN-16558*, were from bulk oak charcoal and have been treated as *termini post quos* for occupation at Tankardstown South.

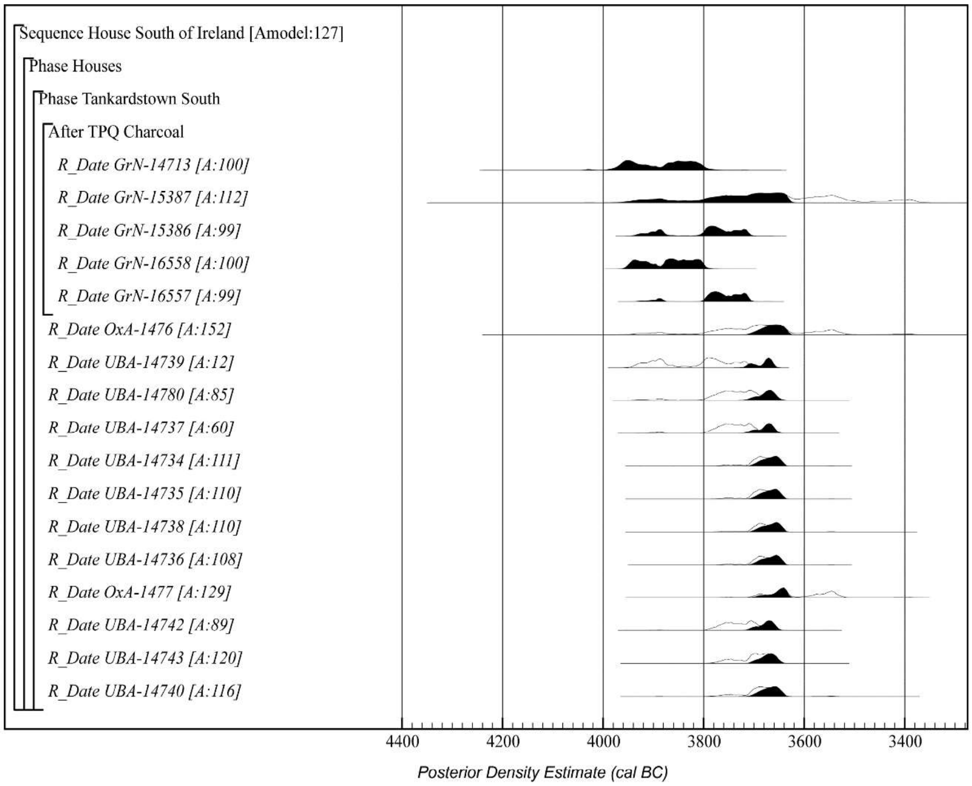

Figure 4.16 Bayesian modelled dates from Tankardstown South, derived from the model shown in Figure 4.20

An obvious omission from this dataset of Early Neolithic houses are the examples from Lough Gur, County Limerick (Ó Ríordáin 1954; Grogan and Eogan 1987; Cleary 1993; 1995; 2000; 2003; 2018; Smyth 2014, 71-81). (For a full site description see Appendix B-54). Two radiocarbon dates were obtained from charcoal recovered during excavations within Circle L, however both contained large offsets of ±240 years (see Table 4.1). The large offsets have resulted in date ranges from the Early Neolithic to the Early Bronze Age being returned for features in Circle L. These radiocarbon dates provide little reliable information for the dating of Early Neolithic activity at Lough Gur and were therefore excluded from the models undertaken in this study.

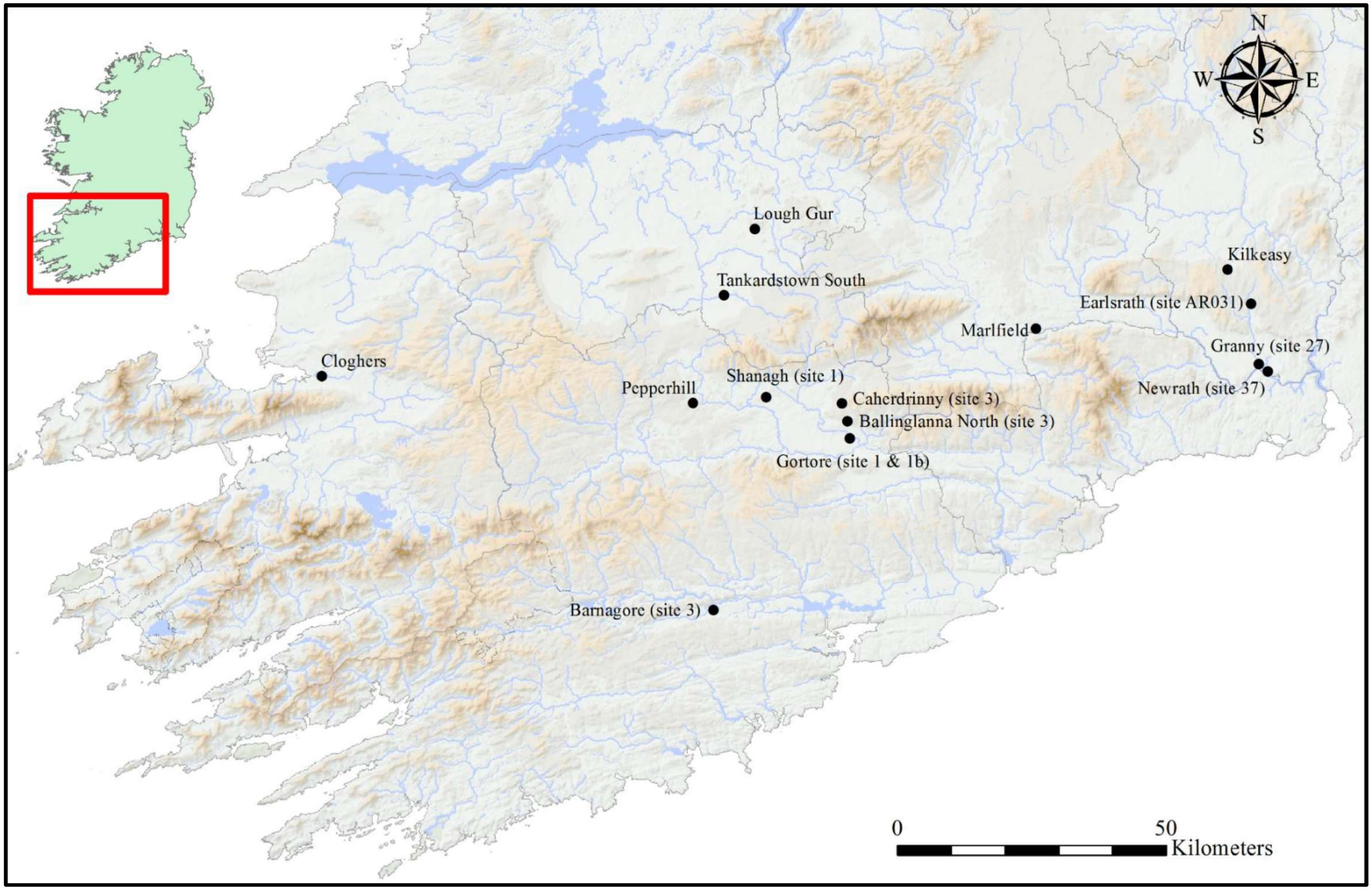

Figure 4.17 Early Neolithic rectangular house sites in southern Ireland

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Ballinglanna North (site 3), County Cork					
UB –13145	C.801 (C.536)	Hazel Charcoal	5010 ± 25	3938-3872 cal BC (31.4%) 3812-3708 cal BC (64.0%)	3908-3880 cal BC (19.7%) 3801-3761 cal BC (37.1%) 3740-3731 cal BC (4.8%) 3725-3714 cal BC (6.5%)
UB – 13146	C.291	Hazel Charcoal	5007 ± 28	3939-3860 cal BC (29.6%) 3813-3706 cal BC (65.8%)	3906-3880 cal BC (15.7%) 3800-3758 cal BC (34.5%) 3744-3714 cal BC (17.9%)
UBA – 10499	C.109	Hazelnut Shells	4936 ± 21	3766-3656 cal BC	3712-3660 cal BC
Barnagore (site 3), County Cork					
Beta – 171411	C.27	Oak Charcoal	4880 ± 70	3922-3920 cal BC (0.1%) 3914-3878 cal BC (2.2%) 3804-3518 cal BC (92.9%) 3393-3388 cal BC (0.2%)	3764-3723 cal BC (12.7%) 3716-3632 cal BC (49.9%) 3556-3539 cal BC (5.6%)
Beta – 171412	C.38	Oak Charcoal	4950 ± 70	3943-3854 cal BC (16.9%) 3846-3830 cal BC (1.7%) 3824-3638 cal BC (76.8%)	3796-3651 cal BC
Caherdrinny (site 3), County Cork					
UBA-13289	C.294	Hazel Charcoal	4877 ± 26	3701-3638 cal BC	3694-3680 cal BC (19.0%) 3665-3641 cal BC (49.2%)
UB–13286	C.877	Hazel Charcoal	4926 ± 26	3766-3650 cal BC	3708-3585 cal BC
UB 13284	C.973	Prunus Charcoal	5138 ± 27	4034-4025 cal BC (1.2%) 3992-3932 cal BC (70.1%) 3874-3808 cal BC (24.1%)	3982-3942 cal BC (64.5%) 3854-3847 cal BC (3.7%)
UBA-13292	C.636	Hazel Charcoal	5214 ± 27	4054-3963 cal BC	4040-4012 cal BC (38.1%) 4004-3980 cal BC (30.1%)
Cloghers, County Kerry					
Beta-134226	Western internal wall	Hazelnut Shell	4850 ± 40	3708-3626 cal BC (69.3%) 3592-3527 cal BC (26.1%)	3694-3678 cal BC (11.2%) 3669-3632 cal BC (45.1%) 3556-3539 cal BC (11.9%)
Beta-134227	Northern wall	Hazelnut Shell	4900 ± 40	3768-3638 cal BC	3704-3648 cal BC
Earlsrath, County Kilkenny					
UBA-14153	C.4 (structure 1)	Oak Charcoal	4912±30	3764-3724 cal BC (10.2%) 3716-3642 cal BC (85.2%)	3702-3656 cal BC (68.2%)
UBA-14154	C.13 (structure 2)	Pine Charcoal	5239±31	4226-4203 cal BC (6.1%) 4167-4128 cal BC (11.7%) 4115-4098 cal BC (2.3%) 4076-3970 cal BC (75.3%)	4143-4138 cal BC (2.2%) 4054-3981 cal BC (66.0%)

Table 4.1 Calibrated radiocarbon dates from Early Neolithic timber houses

Lab Code	**Context**	**Dated Material**	**Radiocarbon Age (Years BP)**	**Calibrated Age (2σ) 95.4% Probability**	**Calibrated Age (1σ) 68.2% Probability**
UBA-14155	*C.45 (structure 1)*	*Alder Charcoal*	*4956±29*	*3788-3660 cal BC*	*3771-3700 cal BC*
UBA-14158	*C.72 (structure 1)*	*Hazelnut Shell*	*4835±41*	*3702-3624 cal BC (51.1%)* *3600-3524 cal BC (44.3%)*	*3660-3630 cal BC (34.4%)* *3578-3534 cal BC (33.8%)*
Gortore (site 1), County Cork					
UB-6769	*C.157*	*Charcoal*	*4972±39*	*3928-3877 cal BC (9.4%)* *3804-3655 cal BC (86.0%)*	*3791-3701 cal BC*
Granny (site 27), County Kilkenny					
UB-6315	*C.27314*	*Oak Charcoal*	*5054 ± 38*	*3960-3765 cal BC (95.0%)* *3722-3718 cal BC (0.4%)*	*3942-3856 cal BC (50.6%)* *3844-3836 cal BC (3.8%)* *3820-3796 cal BC (13.8%)*
UB-6633	*C.27124*	*Oak Charcoal*	*5046 ± 39*	*3956-3761 cal BC (92.6%)* *3740-3731 cal BC (1.2%)* *3725-3714 cal BC (1.7%)*	*3942-3856 cal BC (49.2%)* *3842-3837 cal BC (2.5%)* *3820-3790 cal BC (16.5%)*
UB-6634	*Fill C.27325 of pit C.27322*	*Hazelnut Shell*	*4776 ± 39*	*3646-3511 cal BC (87.9%)* *3424-3382 cal BC (7.5%)*	*3636-3626 cal BC (8.0%)* *3597-3526 cal BC (60.2%)*
UB-6635	*C.27245*	*Elm Charcoal*	*4902 ± 38*	*3766-3638 cal BC*	*3703-3650 cal BC*
UBA-14683	*Fill C.27323 of pit C.27322*	*Wheat Grain*	*4926 ± 33*	*3772-3648 cal BC*	*3712-3654 cal BC*
UBA-14684	*Fill C.27323 of pit C.27322*	*Wheat Grain*	*4911 ± 32*	*3766-3642 cal BC*	*3702-3655 cal BC*
UBA-14685	*Fill C.27325 of pit C.27322*	*Cereal Grain*	*4884 ± 32*	*3712-3635 cal BC*	*3694-3644 cal BC*
UBA-14686	*Fill C.27325 of pit C.27322*	*Cereal Grain*	*4918 ± 32*	*3766-3645 cal BC*	*3707-3655 cal BC*
Kilkeasy, County Kilkenny					
Poz-26458	*C.29*	*Hazelnut Shell*	*4860±40*	*3712-3627 cal BC (79.3%)* *3586-3529 cal BC (16.1%)*	*3695-3636 cal BC*
Poz-26459	*C.29*	*Wheat Grain*	*4840±40*	*3704-3626 cal BC (57.5%)* *3597-3526 cal BC (37.9%)*	*3692-3685 cal BC (3.5%)* *3662-3631 cal BC (40.3%)* *3577-3574 cal BC (1.3%)* *3563-3536 cal BC (23.1%)*
Poz-26460	*C.5*	*Hazelnut Shell*	*4780±40*	*3648-3512 cal BC (88.8%)* *3424-3383 cal BC (6.6%)*	*3637-3626 cal BC (8.7%)* *3597-3526 cal BC (59.5%)*
Poz-26461	*C.3*	*Wheat Grain*	*4820±40*	*3694-3678 cal BC (2.5%)* *3667-3520 cal BC (92.9%)*	*3651-3630 cal BC (23.9%)* *3580-3534 cal BC (44.3%)*

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Poz-25474	*C.3*	*Hazelnut Shell*	*4590±40*	*3511-3425 cal BC (30.7%)* *3383-3316 cal BC (37.8%)* *3293-3288 cal BC (0.3%)* *3274-3266 cal BC (0.6%)* *3238-3108 cal BC (26.1%)*	*3496-3460 cal BC (22.0%)* *3376-3336 cal BC (33.9%)* *3210-3192 cal BC (7.2%)* *3152-3138 cal BC (5.0%)*
Poz-25475	*C.5*	*Wheat Grain*	*4860±35*	*3708-3631 cal BC (85.0%)* *3578-3573 cal BC (0.6%)* *3566-3536 cal BC (9.8%)*	*3694-3678 cal BC (15.4%)* *3668-3636 cal BC (52.8%)*
UBA-10489	*C.36*	*Hazel Charcoal*	*4832±23*	*3656-3630 cal BC (60.3%)* *3579-3534 cal BC (35.1%)*	*3651-3633 cal BC (51.3%)* *3552-3541 cal BC (16.9%)*
Lough Gur (Circle L), County Limerick					
D-40	*Circle L*	*Charcoal*	*4410 ± 240*	*3662-2468 cal BC*	*3497-3454 cal BC (3.4%)* *3377-2860 cal BC (59.7%)* *2808-2756 cal BC (4.0%)* *2719-2704 cal BC (1.1%)*
D-41	*Circle L*	*Charcoal*	*4690 ± 240*	*4036-4021 cal BC (0.2%)* *3995-2874 cal BC (95.2%)*	*3701-3097 cal BC*
Marlfield, County Tipperary					
UBA-14792	*C.4*	*Wheat Grain*	*4800 ± 31*	*3650-3621 cal BC (20.5%)* *3606-3522 cal BC (74.9%)*	*3640-3630 cal BC (12.3%)* *3580-3533 cal BC (55.9%)*
UBA-14793	*C.4*	*Wheat Grain*	*4747 ± 32*	*3636-3506 cal BC (79.5%)* *3427-3381 cal BC (15.9%)*	*3632-3558 cal BC (54.0%)* *3538-3518 cal BC (14.2%)*
Newrath (site 37), County Kilkenny					
UB-6642	*C.17*	*Hazelnut shell*	*5587±40*	*4492-4349 cal BC*	*4453-4369 cal BC*
Pepperhill, County Cork					
GrN-15476	*C.3*	*Charcoal*	*4860±70*	*3796-3511 cal BC (92.7%)* *3424-3382 cal BC (2.7%)*	*3712-3628 cal BC (47.2%)* *3586-3530 cal BC (21.0%)*
UBA-14788	*C.2*	*Cereal grain*	*4892±28*	*3708-3640 cal BC*	*3694-3648 cal BC*
UBA-14789	*C.2*	*Hazelnut shell*	*4860±34*	*3708-3631 cal BC (85.8%)* *3578-3574 cal BC (0.5%)* *3564-3536 cal BC (9.1%)*	*3694-3678 cal BC (14.9%)* *3667-3636 cal BC (53.3%)*
UBA-14790	*C.6*	*Wheat grain*	*4827±28*	*3661-3626 cal BC (45.1%)* *3594-3526 cal BC (50.3%)*	*3652-3632 cal BC (38.2%)* *3558-3538 cal BC (30.0%)*
UBA-14791	*C.6*	*Hazelnut shell*	*4926±30*	*3767-3650 cal BC*	*3711-3654 cal BC*
Shanagh (site 1), County Cork					
UBA-21417	*C.2*	*Hazelnut Shell*	*4870±47*	*3766-3628 cal BC (82.8%)* *3583-3532 cal BC (12.6%)*	*3703-3636 cal BC*

Lab Code	***Context***	***Dated Material***	***Radiocarbon Age (Years BP)***	***Calibrated Age (2σ) 95.4% Probability***	***Calibrated Age (1σ) 68.2% Probability***
UBA-21418	*C.52*	*Hazelnut Shell*	*4850±47*	*3758-3744 cal BC (0.8%)* *3714-3620 cal BC (63.5%)* *3608-3522 cal BC (31.1%)*	*3696-3632 cal BC (55.0%)* *3558-3538 cal BC (13.2%)*
UBA-21419	*C.6*	*Wheat Grain*	*4930±45*	*3796-3640 cal BC*	*3761-3741 cal BC (13.1%)* *3731-3726 cal BC (3.3%)* *3714-3654 cal BC (51.8%)*
Tankardstown South, County Limerick					
GrN-14713	*H1 C.1*	*Oak Charcoal*	*5105±45*	*3984-3790 cal BC*	*3966-3931 cal BC (22.9%)* *3876-3806 cal BC (45.3%)*
GrN-15386	*H1 C.1*	*Oak Charcoal*	*5005±25*	*3934-3874 cal BC (24.6%)* *3808-3707 cal BC (70.8%)*	*3894-3881 cal BC (9.1%)* *3800-3758 cal BC (38.6%)* *3744-3713 cal BC (20.5%)*
GrN-15387	*H1 C.1*	*Oak Charcoal*	*4880±110*	*3948-3498 cal BC (89.7%)* *3437-3378 cal BC (5.7%)*	*3796-3623 cal BC (50.3%)* *3603-352 cal 4BC (17.9%)*
GrN-16557	*H2*	*Oak Charcoal*	*4995±20*	*3906-3880 cal BC (7.1%)* *3800-3706 cal BC (88.3%)*	*3792-3760 cal BC (39.9%)* *3742-3714 cal BC (28.3%)*
GrN-16558	*H2*	*Oak Charcoal*	*5070±20*	*3951-3893 cal BC (33.7%)* *3882-3798 cal BC (61.7%)*	*3944-3927 cal BC (11.9%)* *3878-3804 cal BC (56.3%)*
OxA-1476	*H1 C.23*	*Emmer Wheat Grain*	*4890±80*	*3942-3857 cal BC (7.0%)* *3820-3517 cal BC (87.9%)* *3396-3386 cal BC (0.5%)*	*3779-3633 cal BC (63.6%)* *3556-3539 cal BC (4.6%)*
OxA-1477	*H1 C.23*	*Emmer Wheat Grain*	*4840±45*	*3708-3621 cal BC (55.1%)* *3606-3522 cal BC (40.3%)*	*3692-3684 cal BC (4.8%)* *3664-3631 cal BC (36.4%)* *3578-3573 cal BC (2.5%)* *3566-3536 cal BC (24.5%)*
UBA-14734	*H1 C.1*	*Wheat Grain*	*4895±33*	*3761-3742 cal BC (3.3%)* *3731-3726 cal BC (0.7%)* *3715-3637 cal BC (91.4%)*	*3696-3650 cal BC*
UBA-14735	*H1 C.1*	*Wheat Grain*	*4897±32*	*3761-3742 cal BC (3.3%)* *3731-3726 cal BC (0.7%)* *3715-3637 cal BC (91.4%)*	*3696-3651 cal BC*
UBA-14736	*H1 C.41*	*Wheat Grain*	*4891±31*	*3749-3744 cal BC (0.6%)* *3714-3636 cal BC (94.8%)*	*3695-3648 cal BC*
UBA-14737	*H1 C.41*	*Wheat Grain*	*4958±30*	*3792-3658 cal BC*	*3772-3701 cal BC*
UBA-14738	*H1 C.23*	*Wheat Grain*	*4890±33*	*3761-3742 cal BC (2.5%)* *3730-3726 cal BC (0.5%)* *3715-3636 cal BC (92.4%)*	*3696-3647 cal BC*

Lab Code	*Context*	*Dated Material*	*Radiocarbon Age (Years BP)*	*Calibrated Age (2σ) 95.4% Probability*	*Calibrated Age (1σ) 68.2% Probability*
UBA-14739	*H1 C.23*	*Wheat Grain*	*5013±31*	*3942-3856 cal BC (37.5%)* *3839-3836 cal BC (0.4%)* *3822-3706 cal BC (57.6%)*	*3914-3878 cal BC (23.0%)* *3804-3760 cal BC (31.6%)* *3742-3714 cal BC (13.7%)*
UBA-14740	*H2 C.4*	*Wheat*	*4899±37*	*3766-3637 cal BC*	*3700-3650 cal BC*
UBA-14742	*H2 C.171*	*Cereal*	*4947±30*	*3782-3656 cal BC*	*3764-3694 cal BC (58.2%)* *3680-3666 cal BC (10.0%)*
UBA-14743	*H2 C.171*	*Wheat*	*4923±33*	*3771-3646 cal BC*	*3712-3652 cal BC*
UBA-14780	*H1 C.1*	*Wheat Grain*	*4952±38*	*3890-3886 cal BC (0.6%)* *3798-3651 cal BC (94.8%)*	*3772-3694 cal BC (63.6%)* *3678-3670 cal BC (4.6%)*

4.4.2. The chronology of Early Neolithic houses in southern Ireland.

Fifty-seven radiocarbon determinations (see Table 4.1) from twenty structures at thirteen sites are included in the model to refine the chronology of Early Neolithic timber houses. Twenty-two of these were derived from charcoal samples and are treated as a *termini post quos* for occupation of the structure concerned. The remaining thirty-five radiocarbon dates, all from short-lived organic material, are from nine sites and have been included in the model as dating the occupation of these sites. This would appear to be quite a representative sample, but it should be noted that twelve of these dates are from one site, Tankardstown South. The radiocarbon data from house sites across the region suggests that house construction and occupation covered a tight chronological horizon with all houses likely to have been either in use contemporaneously or for their use to have overlapped.

For this reason, the model defined in Figure 4.20 operates under the prior assumption that the phase of house occupation consisted of a number of sites, which while geographically diverse were chronologically comparable. The model shows good overall agreement ($A_{overall}$=126.6) and all the dates are in good agreement for the start and end date of use of rectangular houses in the region. The only outliers which show poor agreement with the overall model were *UBA-14737* (A= 59.3%; (A'c)=60.0%) and *UBA-14739* (A= 11.2%; (A'c)=60.0%), both from Tankardstown South. These determinations may just be statistical outliers, not unexpected in a series of this size. (For full model specifications see Appendix C.1.1)

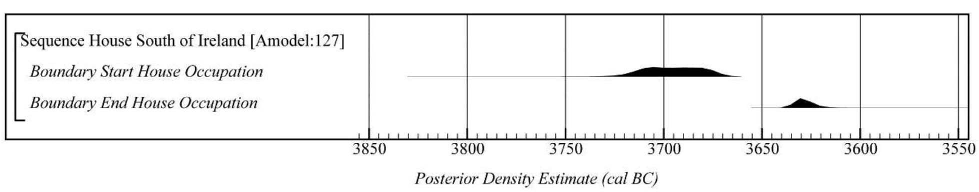

Figure 4.18 Bayesian modelled start and end dates of occupation of Early Neolithic Houses in southern Ireland, derived from the model shown in Figure 4.20

The model defined in Figure 4.20 suggests the occupation of Early Neolithic houses in southern Ireland began in *3730 – 3660 cal BC (95% probability)* probably in *3720 – 3670 cal BC (68% probability)*. These structures were in use until *3640 – 3610 cal BC (95% probability)* probably until *3640 – 3620 cal BC (68% probability).* This compares well with the chronology proposed by McSparron (2008), which refined the chronology of occupation of Early Neolithic timber houses to between *3715 – 3650 cal BC (95% probability), 3705 – 3650 cal BC (68% probability* and *3690 – 3620 cal BC (95% probability), 3660 – 3630 cal BC (68% probability)*, and Cooney *et al.* (2011) which proposed a date range for construction of Early Neolithic house in Ireland beginning in *3730 – 3660 cal BC (95% probability) 3715 – 3680 cal BC (68% probability)* and being in use until *3640 – 3605 cal BC (95% probability) 3635 – 3615 cal BC (68% probability)*. The model presented here shows that the activity represented by the use of Early Neolithic houses in southern Ireland lasted a relatively short period of time *30 – 100 years (95% probability)* probably for *40 – 80 years (68% probability)* possibly representing three or four generations in human terms.

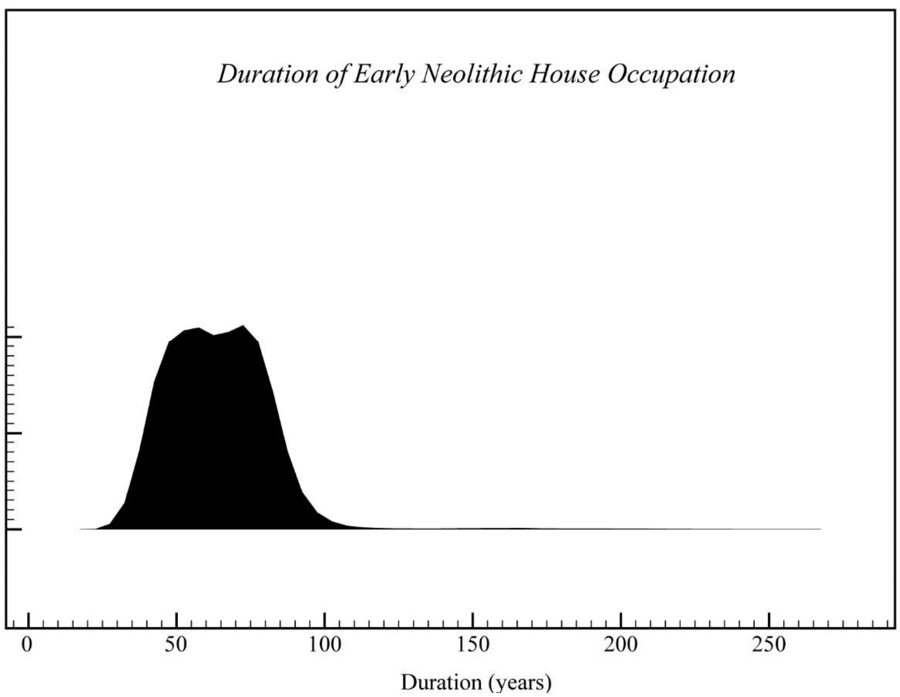

Figure 4.19 Duration of Early Neolithic house occupation in southern Ireland, derived from the model shown in Figure 4.20

This analysis again demonstrates the importance of obtaining radiocarbon dates from short-lived, single-entity samples (Ashmore 1999; McSparron 2008; Whittle *et al.* 2011). The accuracy of the date range estimates and the seemingly short period of occupation at these sites demonstrates that even a relatively limited 'old wood' effect is significant in Bayesian modelling and in particular archaeological interpretation. On present evidence, Early Neolithic timber houses were constructed in the latter quarter of the 38th century cal BC. On the basis of the chronological model proposed here (see below) and elsewhere (Cooney *et al.* 2011; Whitehouse *et al.* 2014), these structures cannot be seen as belonging to the entirety of the Early Neolithic but to a tightly defined period within it. This 'house horizon' and the occupation period at these sites appears to concentrate on the final quarter of the 38th century cal BC and the first three quarters of the 37th century cal BC and given the close association between these structures and the earliest evidence for cereals on the island (McClatchie *et al.* 2014) questions arise as to whether those who constructed and use them were the first generations of the Irish Neolithic.

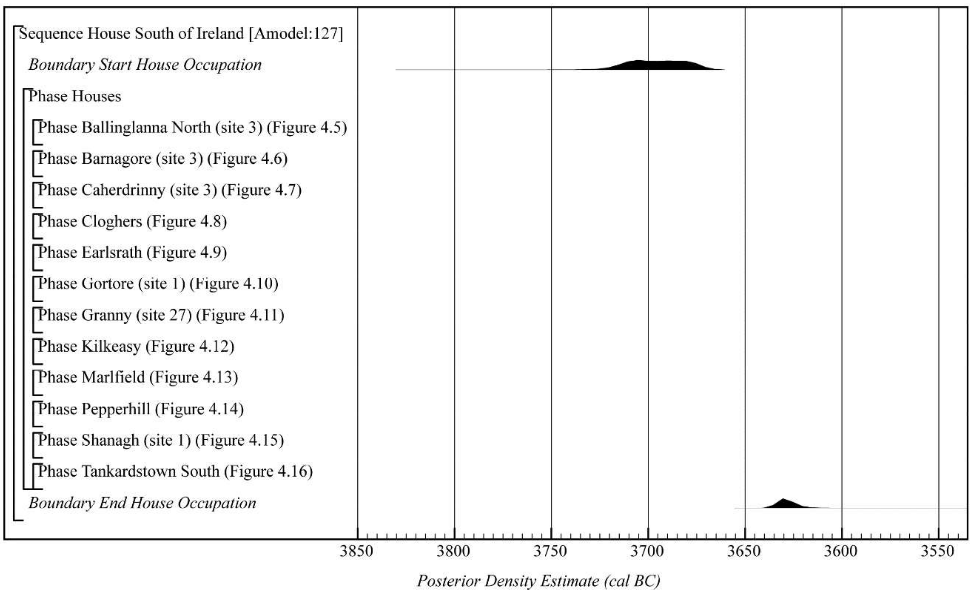

Figure 4.20 Bayesian model for occupation of Early Neolithic houses in southern Ireland

4.4.3. Early Neolithic ephemeral sites in southern Ireland.

Although they have attracted much research attention, timber houses are not the only manifestation of Early Neolithic settlement. Other features including artefacts scatters, pits, hearths, and scatterings of post and stake-holes are also uncovered in the vicinity of houses or as isolated features (Smyth 2012). In addition to the Early Neolithic timber houses, this study also examined the chronology of these features to better define the scope of the Early Neolithic in the region.

One of the problems encountered is that these site types have been sampled far less intensively for archaeobotanical remains, and so provided less opportunities for the radiocarbon dating (McLaughlin *et al.* 2016). Sites and features included in this section are only incorporated into the model if they are dated with short-lived, single-entity samples to the Early Neolithic or in the case of charcoal derived radiocarbon dates the dating context is supported by the occurrence of diagnostically Early Neolithic material. Where dates derived from charcoal samples are not found with this diagnostic material these dates are excluded from the model. In concurrence with the models proposed for timber houses all charcoal dates are treated as *termini post quos* for activity at the site.

Caherabbey Upper (site 185.1-4), County Tipperary.

The remains of a possible structure were identified in Area 1, in advance of road construction at Caherabbey Upper, County Tipperary (Molloy 2007b). (For a full site description see Appendix B-22). Initially a single radiocarbon date *UB-7236* was obtained from oak charcoal*,* this has been treated as *terminus post quem* for activity at the site.

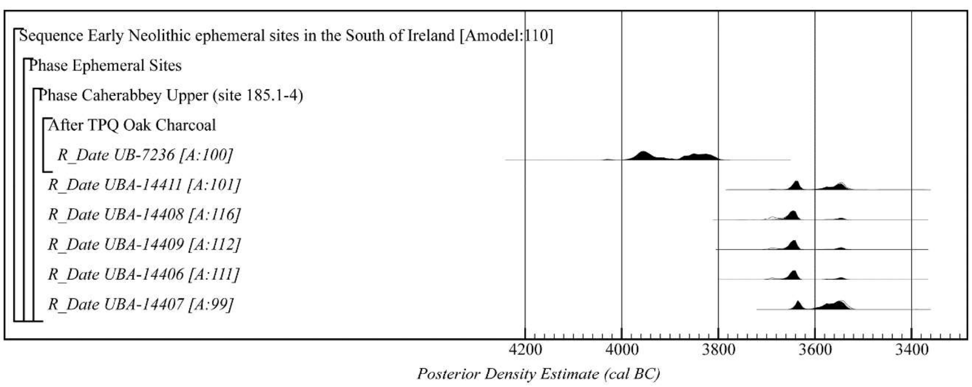

Figure 4.21 Bayesian modelled dates from Caherabbey Upper (site 185.1-4), derived from the model shown in Figure 4.30

Five Early Neolithic radiocarbon dates, *UBA-14406, UBA-14407, UBA-14408, UBA-14409, UBA-14410* and *UBA-14411* were later obtained from emmer wheat grains (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Two statistically consistent radiocarbon dates, *UBA-14406* and *UBA-14407* (T'=1.5; T'(5%)=3.8; v=1) (Ward and Wilson 1978) from pit F.37, two statistically consistent radiocarbon dates *UBA-14408* and *UBA-14409* (T'=0.0; T'(5%)=3.8; v=1) (*ibid.*) from pit F.81 were included in the Bayesian model for activity at Caherabbey Upper (site 185.1-4). *UBA-14410* and *UBA-14411* from post-hole F.53 were shown to be statistically inconsistent (T'=6; T'(5%)=3.8; v=1) (*ibid.*), however *UBA-14411* was shown to be statistically consistent with the other dates from Caherabbey Upper (site 185.1-4) (T'=2.7; T'(5%)=9.5; v=4) (*ibid.*) and was therefore also included in the model. *UB-7236* was obtained from oak charcoal and has been treated as *terminus post quem* for activity at the site.

Kilsheelan, County Tipperary.

The site was identified in advance of a housing development at Kilsheelan, County Tipperary (Drum 2007). (For a full site description see Appendix B-50). *UB-6961* and *UB-6960* were obtained from charcoal from fills C.14 and C.15 of pit C.13. *UBA-14670* was derived from cereal grains from fill C.14 of pit C.13, while *UBA-14671, UBA-14672* and *UBA-14673* were obtained from cereal grains recovered from fill C.15 of pit C.13 (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). The radiocarbon date *UB-6961* from fill C.14 of pit C.15, despite being derived from charcoal, was shown to be statistically consistent with *UBA-14670* from fill C.14 of pit C.15 (T'=0.0; T'(5%)=3.8; v=1) (Ward and Wilson 1978) and was therefore included in the Bayesian model for activity at Killsheelan along with the three radiocarbon dates *UBA-14671, UBA-14672* and *UBA-14673* from fill C.15 of pit C.13. *UB-6960*, also from charcoal, was statistically inconsistent with *UBA-14671, UBA-14672* and *UBA-14673* also from fill C.15 of pit C.13 and has been treated as *terminus post quem* for activity at the site.

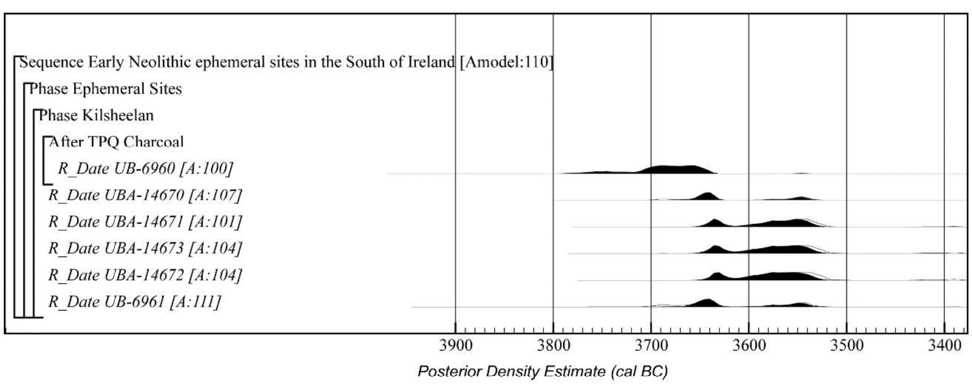

Figure 4.22 Bayesian modelled dates from Kilsheelan, derived from the model shown in Figure 4.30

Newrath (site 35), County Kilkenny.

Early Neolithic activity was identified at Newrath 35, County Kilkenny (Wilkins 2006) in advance of road construction. (For a full site description see Appendix B-62). Four radiocarbon dates *UB 6639, UBA-14798*, *UBA-14799* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016) (emmer wheat grains) and *UB-6640* (charred hazelnut shells) were obtained from short-lived material and have been included in the model.

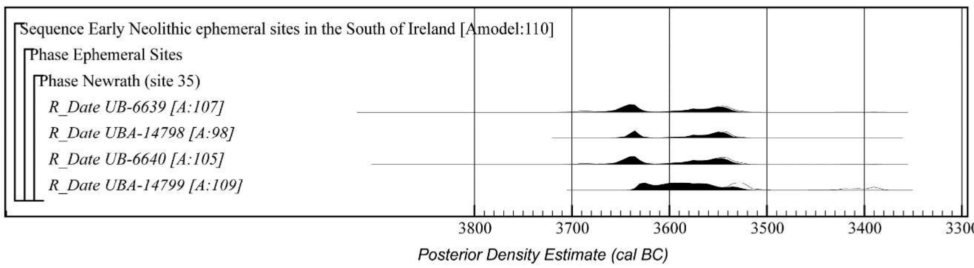

Figure 4.23 Bayesian modelled dates from Newrath (site 35), derived from the model shown in Figure 4.30

Scart, County Kilkenny.

Early Neolithic activity was identified at Scart, County Kilkenny (Monteith 2011) in advance of road construction. (For a full site description see Appendix B-68). There radiocarbon dates from the Early Neolithic were obtained during excavation, *UBA-13996* and *Poz-26454* from charred hazelnut shells have been treated as dating to the occupation phase at the site. A further sample *UBA-13993* from oak charcoal was treated as *terminus post quem* for activity at the site.

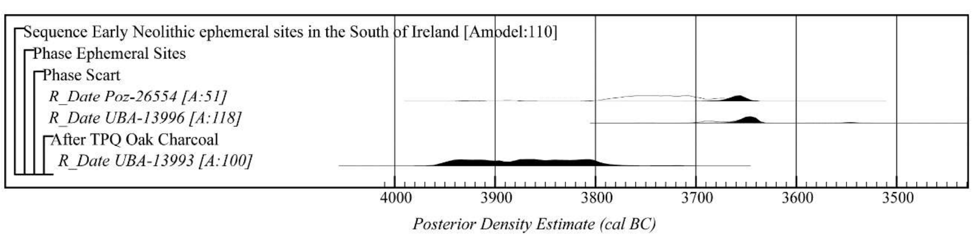

Figure 4.24 Bayesian modelled dates from Scart, derived from the model shown in Figure 4.30

Suttonrath (site 206.1), County Tipperary.

Early Neolithic activity was identified at Suttonrath, County Tipperary (McQuade 2007b) in advance of road construction. (For a full site description see Appendix B-71). A single radiocarbon date, *UB-7208*, from oak samples was obtained during excavation while *UBA-14809* and *UBA-14810* were derived from charred cereal grains (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). *UB-7208* despite being derived from charcoal was shown to be statistically consistent with both *UBA-14809* (T'=1.1; T'(5%)=3.8: v=1) (Ward and Wilson 1978) and *UBA-14810* (T'=0.6; T'(5%)=3.8; v=1) (*ibid.*) and was therefore included in the model.

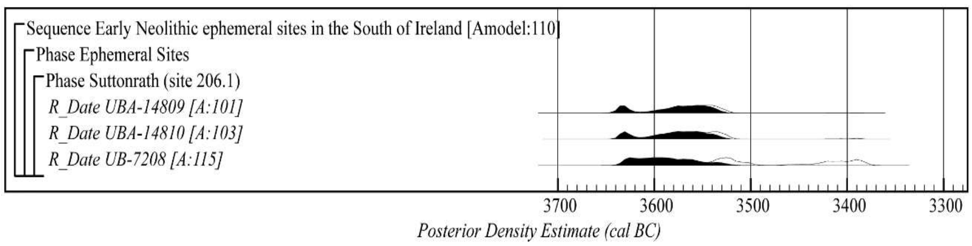

Figure 4.25 Bayesian modelled dates from Suttonrath (site 206.1), derived from the model shown in Figure 4.30

Additional sites included in this model are the pit and post-hole sites of Ballinaspig More (site 4) (Danaher and Cagney 2004c), Ballinaspig More (site 5) (Danaher and Cagney 2004b), Bawnfune (site 2) (Lennon 2009), Curraghprevin (site 3) (O'Neill 2006), Danganbeg (site 10-5) (Hull 2015), Manor East (site 1) (Clarke 2012), Manor West (Long 2012), Monadreela (site 7) (O'Brien 2014a) and Monadreela (site 9) (O'Brien 2014b) each of which returned Early Neolithic radiocarbon dates in association with diagnostically Early Neolithic material. More details of these radiocarbon dates are available in Table 4.2 and Appendix B. Four sites, Ballynacarriga (site 3) (Lehane and Leigh 2010), Ballynamona (site 1) (Johnston and Tierney 2011), Corrin (site 1) (O'Connell 2006) and Monadreela (site 11) (O'Brien 2014e), despite returning radiocarbon dates from the Early Neolithic were not included in the model. These sites were deemed to potentially be susceptible to the 'old wood' effect as each date was derived from charcoal and the sites lacked diagnostically Early Neolithic material.

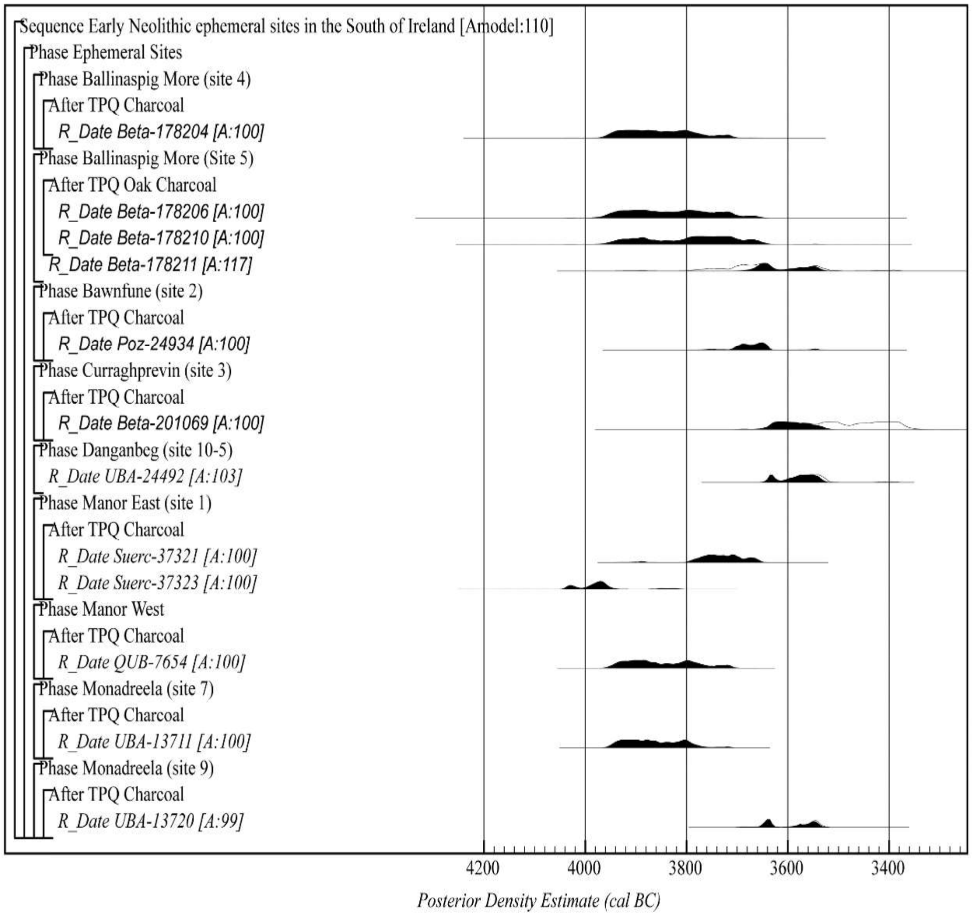

Figure 4.26 Bayesian modelled dates from Ballinaspig More (sites 4 & 5), Bawnfune (site 2), Curraghprevin (site 3), Danganbeg (site 10-5), Manor East (site 1), Manor West, and Monadreela (sites 7 & 9), derived from the model shown in Figure 4.30

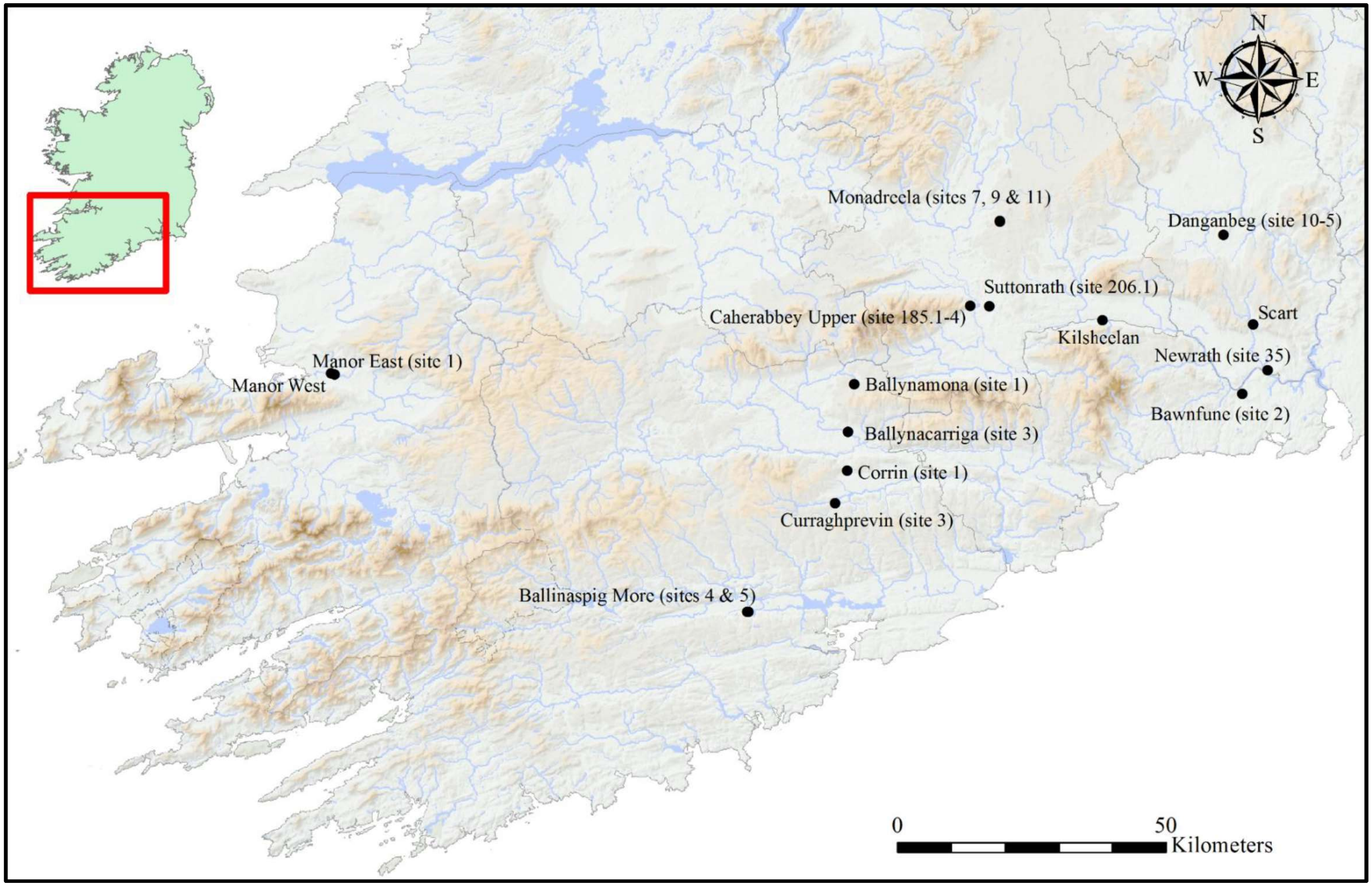

Figure 4.27 Early Neolithic ephemeral sites in southern Ireland

Lab Code	*Context*	*Dated Material*	*Radiocarbon Age (Years BP)*	*Calibrated Age (2σ) 95.4% Probability*	*Calibrated Age (1σ) 68.2% Probability*
Ballinaspig More (site 4), County Cork					
Beta - 178204	*C.03*	*Alder Charcoal*	*5050 ± 50*	*3960-3712 cal BC (95.4%)*	*3942-3854 cal BC (45.6%)* *3846-3830 cal BC (7.0%)* *3824-3792 cal BC (15.5%)*
Ballinaspig More (site 5), County Cork					
Beta – 178206	*C.55*	*Oak Charcoal*	*5030 ± 70*	*3965-3693BC (93.5%)* *3681-3665BC (1.9%)*	*3942-3854BC (36.4%)* *3846-3831BC (5.2%)* *3824-3764BC (23.9%)* *3723-3716BC (2.6%)*
Beta-178207	*C.1090*	*Alder Charcoal*	*4710 ± 70*	*3636-3367BC (95.4%)*	*3628-3584BC (18.1%)* *3532-3496BC (14.8%)* *3460-3376BC (35.3%)*
Beta - 178210	*C.1134*	*Oak Charcoal*	*4990 ± 70*	*3946-3656BC (95.4%)*	*3932-3875BC (19.8%)* *3806-3696BC (48.4%)*
Beta - 178211	*C.1149*	*Wheat Grain*	*4860 ± 70*	*3796-3511BC (92.7%)* *3424-3382BC (2.7%)*	*3712-3628BC (47.2%)* *3586-3530BC (21.0%)*
Ballynacarriga (site 3), County Cork					
UB-13169	*C.507*	*Charcoal*	*4969±25*	*3796-3692 cal BC (92.3%)* *3681-3664 cal BC (3.1%)*	*3768-3709 cal BC*
Ballynamona (site 1), County Cork					
UB-12975	*C.86*	*Hazel/Alder Charcoal*	*4912 ± 25*	*3761-3742 cal BC (3.6%)* *3728-3726 cal BC (0.3%)* *3715-3643 cal BC (91.5%)*	*3700-3658 cal BC*
Bawnfune (site 2), County Waterford					
Poz-24934	*F.019*	*Hazel Charcoal*	*4880 ± 40*	*3764-3722 cal BC (5.9%)* *3716-3632 cal BC (86.4%)* *3556-3538 cal BC (3.1%)*	*3696-3641 cal BC*
Caherabbey Upper (site 185.1-4), County Tipperary					
UB-7236	*F.53*	*Oak Charcoal*	*5119 ± 38*	*3986-3892 cal BC (46.8%)* *3883-3798 cal BC (48.6%)*	*3971-3936 cal BC (29.4%)* *3870-3812 cal BC (38.8%)*
UBA-14406	*F.37*	*Wheat Grain*	*4849 ± 28*	*3700-3631 cal BC (81.2%)* *3578-3574 cal BC (0.6%)* *3565-3536 cal BC (13.6%)*	*3661-3633 cal BC (62.0%)* *3551-3542 cal BC (6.2%)*
UBA-14407	*F.37*	*Wheat Grain*	*4801 ± 28*	*3647-3624 cal BC (20.0%)* *3601-3524 cal BC (75.4%)*	*3640-3630 cal BC (12.2%)* *3578-3534 cal BC (56.0%)*
UBA-14408	*F.81*	*Wheat Grain*	*4856 ± 30*	*3705-3631 cal BC (86.6%)* *3561-3536 cal BC (8.8%)*	*3692-3685 cal BC (6.2%)* *3662-3636 cal BC (62.0%)*

Table 4.2 Calibrated radiocarbon dates from Early Neolithic ephemeral sites.

Lab Code	***Context***	***Dated Material***	***Radiocarbon Age (Years BP)***	***Calibrated Age (2σ) 95.4% Probability***	***Calibrated Age (1σ) 68.2% Probability***
UBA-14409	*F.81*	*Wheat Grain*	*4850 ± 29*	*3702-3631 cal BC (81.6%)* *3577-3574 cal BC (0.5%)* *3564-3536 cal BC (13.3%)*	*3662-3634 cal BC (63.2%)* *3550-3543 cal BC (5.0%)*
UBA-14410	*F.53*	*Wheat Grain*	*4693 ± 43*	*3631-3566 cal BC (17.8%)* *3536-3368 cal BC (77.6%)*	*3618-3611 cal BC (3.5%)* *3521-3495 cal BC (15.0%)* *3463-3376 cal BC (49.7%)*
UBA-14411	*F.53*	*Wheat Grain*	*4822 ± 30*	*3658-3626 cal BC (37.2%)* *3597-3526 cal BC (58.2%)*	*3650-3631 cal BC (30.5%)* *3577-3574 cal BC (1.9%)* *3564-3536 cal BC (35.8%)*
Corrin (site 1), County Cork					
Beta-201027	*C.121*	*Oak Charcoal*	*5090 ± 40*	*3968-3794 cal BC*	*3958-3930 cal BC (18.5%)* *3876-3805 cal BC (49.7%)*
Curraghprevin (site 3), County Cork					
Beta - 201069	*F.44*	*Charcoal*	*4720 ± 80*	*3651-3356BC (95.4%)*	*3632-3561BC (25.0%)* *3536-3497BC (14.5%)* *3456-3377BC (28.6%)*
Danganbeg (site 10-5), County Kilkenny					
UBA-24492	*C.1010*	*Emmer Wheat*	*4788±33*	*3646-3518 cal BC*	*3638-3628 cal BC (9.5%)* *3586-3530 cal BC (58.7%)*
Killsheelan, County Tipperary					
UB-6960	*Fill C.15 of C.13*	*Charcoal*	*4900±41*	*3771-3637 cal BC*	*3706-3646 cal BC*
UB-6961	*Fill C.14 of C.13*	*Charcoal*	*4841±39*	*3704-3626 cal BC (59.2%)* *3597-3526 cal BC (36.2%)*	*3692-3685 cal BC (4.2%)* *3663-3632 cal BC (42.5%)* *3561-3537 cal BC (21.6%)*
UBA-14670	*Fill C.14 of C.13*	*Emmer Wheat Grain*	*4839±30*	*3696-3628 cal BC (63.7%)* *3584-3532 cal BC (31.7%)*	*3656-3632 cal BC (49.8%)* *3556-3539 cal BC (18.4%)*
UBA-14671	*Fill C.15 of C.13*	*Emmer Wheat Grain*	*4799±33*	*3651-3618 cal BC (20.8%)* *3611-3521 cal BC (74.6%)*	*3641-3629 cal BC (12.4%)* *3583-3532 cal BC (55.8%)*
UBA-14672	*Fill C.15 of C.13*	*Emmer Wheat Grain*	*4786±34*	*3647-3518 cal BC (94.9%)* *3393-3389 cal BC (0.5%)*	*3638-3628 cal BC (9.1%)* *3588-3530 cal BC (59.1%)*
UBA-14673	*Fill C.15 of C.13*	*Indeterminate Cereal Grain*	*4793±36*	*3651-3518 cal BC*	*3640-3628 cal BC (10.9%)* *3587-3530 cal BC (57.3%)*
Manor East (site 1), County Kerry					
Suerc-37321	*C.214*	*Hazel Charcoal*	*4955 ± 35*	*3798-3652 cal BC*	*3774-3695 cal BC*
Suerc-37323	*C.729*	*Oak Charcoal*	*5165 ± 35*	*4044-3940 cal BC (89.2%)* *3857-3817 cal BC (6.2%)*	*4036-4022 cal BC (12.1%)* *3994-3954 cal BC (56.1%)*
Manor West, County Kerry					
QUB-7654	*Unknown*	*Charcoal*	*5036±40*	*3951-3758 cal BC (88.5%)* *3744-3713 cal BC (6.9%)*	*3941-3857 cal BC (46.5%)* *3818-3776 cal BC (21.7%)*

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Monadreela (site 7), County Tipperary					
UBA-13711	*C.82*	*Oak Charcoal*	*5050 ± 32*	*3956-3771 cal BC*	*3941-3856 cal BC (53.5%)* *3818-3794 cal BC (14.7%)*
Monadreela (site 9), County Tipperary					
UBA-13720	*C.98*	*Holly Charcoal*	*4822 ± 32*	*3661-3623 cal BC (36.4%)* *3602-3524 cal BC (59.0%)*	*3650-3631 cal BC (29.1%)* *3578-3574 cal BC (3.1%)* *3565-3536 cal BC (36.1%)*
Monadreela (site 11), County Tipperary					
UBA-13730	*Fill C.27 of pit C.23*	*Oak Charcoal*	*5049 ± 22*	*3946-3788 cal BC*	*3937-3863 cal BC (56.8%)* *3812-3797 cal BC (11.4%)*
Newrath (site 35), County Kilkenny					
UBA-14798	*Fill C.48 of pit C.46*	*Emmer Wheat Grain*	*4809±26*	*3650-3626 cal BC (25.2%)* *3597-3526 cal BC (70.2%)*	*3643-3631 cal BC (18.7%)* *3578-3574 cal BC (4.0%)* *3565-3536 cal BC (45.5%)*
UBA-14799	*C.28*	*Emmer Wheat Grain*	*4754±27*	*3636-3514 cal BC (88.0%)* *3422-3404 cal BC (3.0%)* *3399-3384 cal BC (4.4%)*	*3632-3619 cal BC (10.5%)* *3610-3558 cal BC (43.6%)* *3538-3521 cal BC (14.1%)*
UB-6639	*Fill C.47 of pit C.46*	*Emmer Wheat Grain*	*4827 ± 39*	*3696-3622 cal BC (42.2%)* *3606-3522 cal BC (53.2%)*	*3654-3630 cal BC (30.0%)* *3578-3535 cal BC (38.2%)*
UB-6640	*C.85*	*Hazelnut Shell*	*4821 ± 38*	*3694-3678 cal BC (2.3%)* *3666-3618 cal BC (33.4%)* *3610-3521 cal BC (59.7%)*	*3651-3630 cal BC (24.6%)* *3579-3534 cal BC (43.6%)*
Scart, County Kilkenny					
UBA-13993	*C.525*	*Oak Charcoal*	*5065±31*	*3956-3791 cal BC*	*3943-3908 cal BC (21.8%)* *3879-3801 cal BC (46.4%)*
UBA-13996	*C.844*	*Hazelnut Shell*	*4861±28*	*3702-3633 cal BC (92.5%)* *3552-3542 cal BC (2.9%)*	*3692-3686 cal BC (6.6%)* *3662-3637 cal BC (61.6%)*
Poz-26554	*C.270*	*Hazelnut Shell*	*4960±40*	*3909-3878 cal BC (4.6%)* *3802-3651 cal BC (90.8%)*	*3782-3695 cal BC*
Suttonrath (site 206.1), County Tipperary					
UB-7208	*C.2*	*Charcoal*	*4744 ± 36*	*3637-3500 cal BC (75.4%)* *3432-3378 cal BC (20.0%)*	*3633-3556 cal BC (49.1%)* *3539-3516 cal BC (14.0%)* *3396-3386 cal BC (5.1%)*
UBA-14809	*C.2*	*Wheat*	*4789 ± 24*	*3641-3622 cal BC (15.0%)* *3604-3523 cal BC (80.4%)*	*3637-3630 cal BC (8.2%)* *3578-3534 cal BC (60.0%)*
UBA-14810	*C.2*	*Cereal*	*4778 ± 26*	*3640-3618 cal BC (14.7%)* *3611-3521 cal BC (80.7%)*	*3634-3628 cal BC (6.2%)* *3586-3530 cal BC (62.0%)*

4.4.4. The chronology of Early Neolithic ephemeral sites in southern Ireland.

In order to place the estimates for the dates of timber houses in context, it is necessary to consider the chronology of other aspects of the Early Neolithic in the region. While timber houses possible represent the best source of information about settlement activity in the Early Neolithic, any study of the period would surely be incomplete if other sites of occupation activity were omitted. With this in mind the following section explores the chronology of ephemeral features, such as pit and post-holes, which demonstrate activity during the Early Neolithic. Thirty-five radiocarbon determinations (see Table 4.2) from fourteen sites are included in this model, fourteen of which were derived from charcoal samples are treated as a *termini post quos* for activity at the site concerned (two charcoal derived dates were shown to be statistically consistent with short-lived derived dates from the same context and included in the model).

The remaining nineteen radiocarbon dates, all from short-lived organic material (plus the two charcoal derived dates), are from seven sites and have been included in the model as dating the activity at the sites concerned. The model shows good overall agreement ($A_{overall}$=111.5) the only outlier which shows poor agreement with the overall model is *Poz-26554* from Scart (A=50.9%; (A'c)= 60.0%). This determination may just be a statistical outlier, not unexpected in a series of this size. (For full model specifications see Appendix C.1.2.)

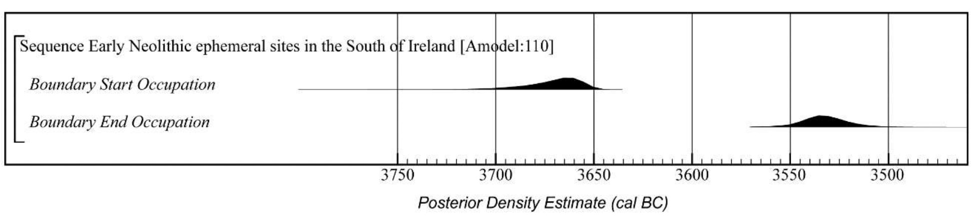

Figure 4.28 Bayesian modelled dates from start and end of Early Neolithic ephemeral site occupation in southern Ireland, derived from the model shown in Figure 4.30

The model defined in Figure 4.30 suggests that the activity at Early Neolithic ephemeral sites in southern Ireland began in *3710 – 3640 cal BC (95% probability), 3680 – 3650 cal BC (68% probability)*. These sites were in use until *3570 – 3500 cal BC (95% probability), 3550 – 3520 cal BC (68% probability).* This model demonstrates that the use of sites lasted for a slightly longer period than rectangular houses, *90 – 170 years (95% probability), 100 – 140 years (68% probability)*, possibly representing four to six generations in human terms. These estimates are independent of those derived from dates of Early Neolithic timber houses and provided an additional source of information regarding the chronology of Early Neolithic settlement activity in the region. However, it should be noted that this model represents a restricted dataset and may not include chronologies for other potential Early Neolithic ephemeral sites. The exclusion of further 4th millennium cal BC radiocarbon dates, which were obtained from site lacking diagnostically Early Neolithic material, may have an effect on the resulting models.

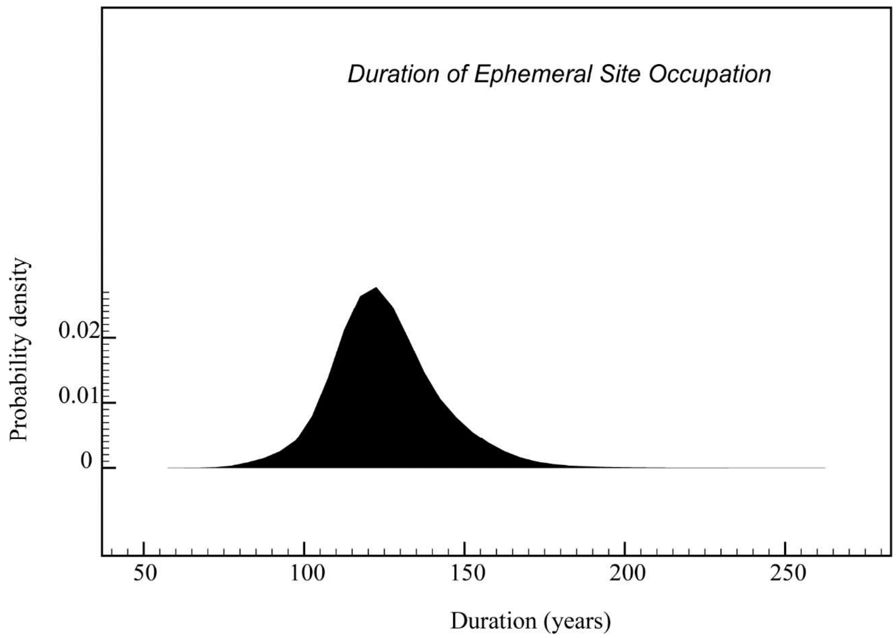

Figure 4.29 Duration of Early Neolithic ephemeral site occupation in southern Ireland, derived from the model shown in Figure 4.30

Despite the limitations of his model, it does demonstrate that activity at these ephemeral sites likely ran parallel with occupation at timber houses but also continued when use of timber houses appears to have fallen out of practice. The overlapping use of house and ephemeral sites may suggest that despite a considerable degree of permanent settlement an element of mobility persisted. The continued use of ephemeral sites following the abandonment of structurally robust timber houses could possibly indicate a shift to a less well-defined and less sedentary lifeway in the post-'House Horizon' Neolithic. While the presence of cereal remains at these sites demonstrates the continued reliance on arable agriculture, the end of the timber house use may indicate a move towards a shifting cultivation regime. This will be discussed in more detail later.

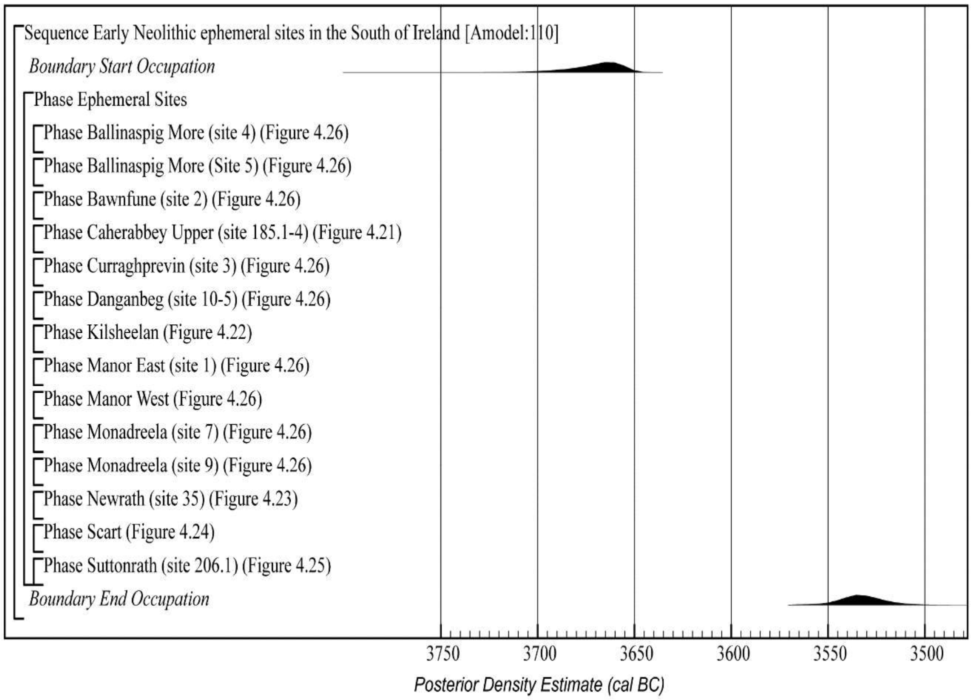

Figure 4.30 Bayesian model for occupation of Early Neolithic ephemeral sites in southern Ireland

4.4.5. Burials.

The previous two sections have explored the chronology of what can be best termed as settlement activity associated with diagnostically Early Neolithic material in southern Ireland. However further radiocarbon data related to non-settlement Neolithic practices in the region has also been identified and must be considered to provide an accurate reflection of the Early Neolithic in the region.

The burial record of the Early Neolithic in Ireland has tended to focus on the extant portal and court tombs dispersed across the landscape. Despite the presence of twenty-one such examples in the study region, excavated examples are rare. Two of these monuments have been excavated, the court tomb at Baile na Móna Íochtarach/Ballynamona Lower, County Waterford (Powell 1938) and the portal tomb at Killaclohane, County Kerry (Connolly 2015). While both demonstrated activity from the Early Neolithic, no radiocarbon dates are yet available and so cannot be included in the models undertaken here. Early Neolithic burial activity in the region is therefore confined to the four excavated examples of isolated or cave burials from Annagh, County Limerick (Ó Floinn 1992; Dowd 2008; Ó Floinn 2011; Ó Donnabháin 2011) (For a full site description see Appendix B-2), Newtown (Carrigdirty Rock site 5), County Limerick (O'Sullivan 2001, 73-86; Woodman 2016, 16) (For a full site description see Appendix B-64), Kilgreany Cave, County Waterford (Tratman *et al.* 1928; Movius 1935; Molleson 1985-6; Woodman *et al.* 1997; Moore 1999; Dowd 2002) (For a full site description see Appendix B-48) and Lough Gur (site 10), County Limerick (Brindley and Lanting 1989; Cleary 1995) (For a full site description see Appendix B-54).

The twelve radiocarbon dates (see Table 4.3) available from excavations at these sites have been included in the model dating the start of burial activity in the region. The model shows good overall agreement ($A_{overall}$=91.4), the only outlier which shows poor agreement with the overall model is *GrA-1708* from Annagh Cave (A=51.4%; (A'c)= 60.0%). The model defined in Figure 4.31 suggests that burial activity in southern Ireland began in *3680 – 3530 cal BC (95% probability), 3650 – 3570 cal BC (68% probability)*. These sites were in use until *3630 – 3390 cal BC (95% probability), 3590 – 3490 cal BC (68% probability).* (For full model specifications see Appendix C.1.3).

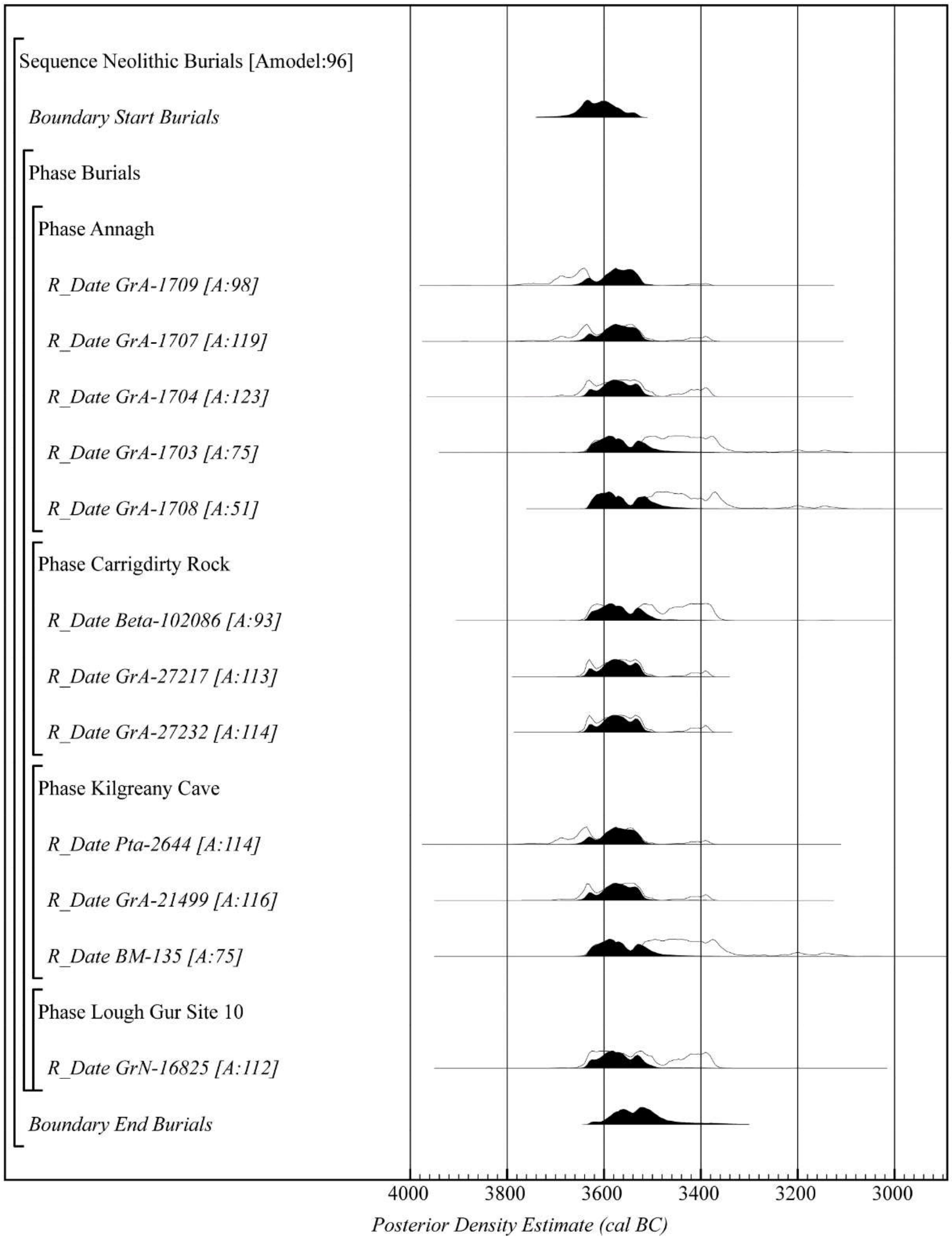

Figure 4.31 Bayesian model for Early Neolithic burials in southern Ireland

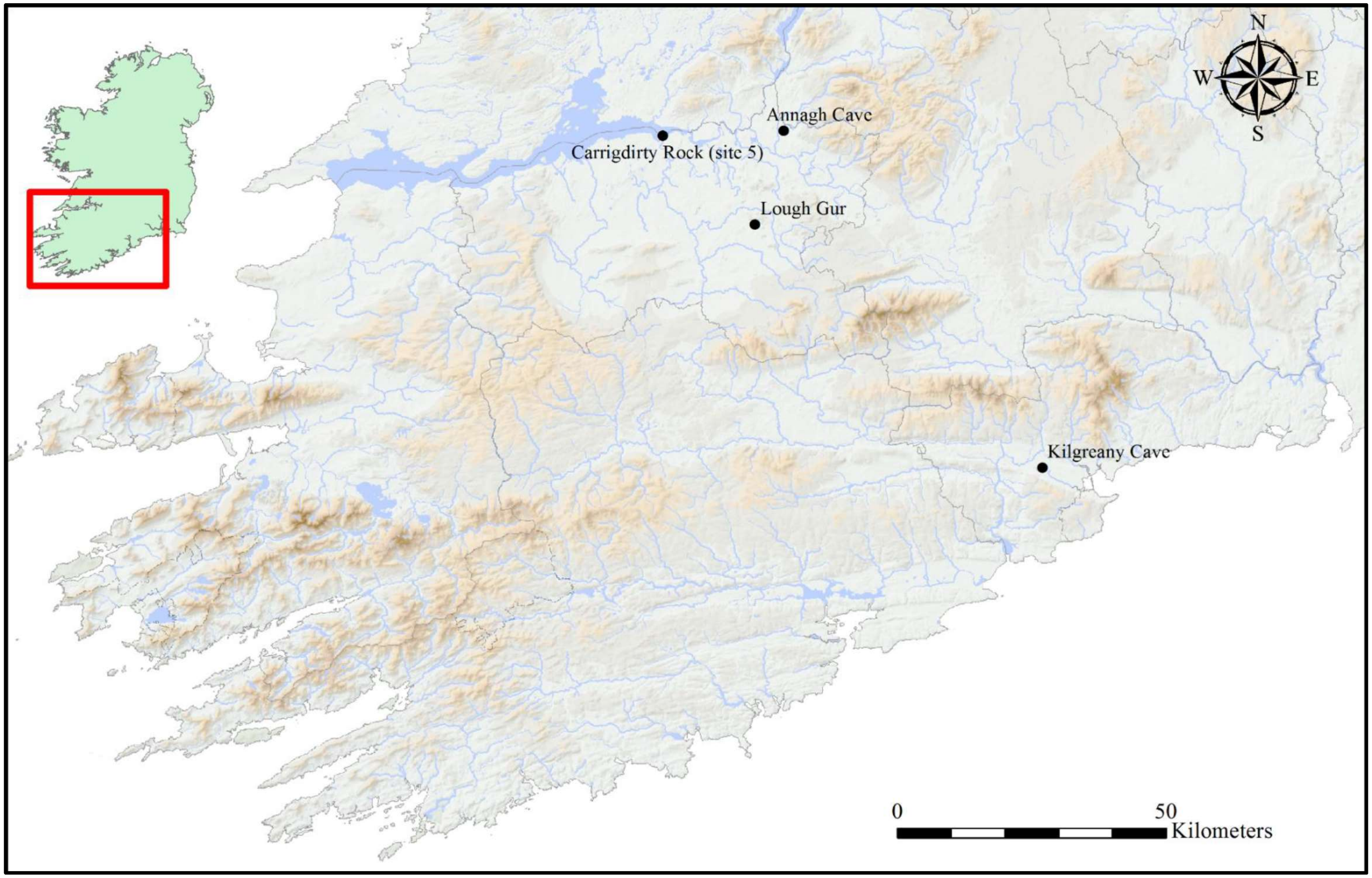

Figure 4.32 Early Neolithic burials in southern Ireland

Lab Code	*Context*	*Dated Material*	*Radiocarbon Age (years BP)*	*Calibrated Age (2σ) 95.4% Probability*	*Calibrated Age (1σ) 68.2% Probability*
Annagh Cave, County Limerick					
GrA-1703	*Burial1*	*Right scapula*	*4670±70*	*3639-3336 cal BC (93.8%)* *3210-3192 cal BC (1.0%)* *3151-3138 cal BC (0.7%)*	*3620-3610 cal BC (3.3%)* *3522-3367 cal BC (64.9%)*
GrA-1704	*Burial 2*	*Right scapula*	*4780±60*	*3660-3494 cal BC (77.1%)* *3464-3375 cal BC (18.3%)*	*3642-3519 cal BC*
GrA-1707	*Burial 3*	*Right scapula*	*4810±60*	*3706-3500 cal BC (87.2%)* *3432-3379 cal BC (8.2%)*	*3655-3621 cal BC (19.0%)* *3607-3522 cal BC (49.2%)*
GrA-1708	*Burial 4*	*Right scapula*	*4640±60*	*3633-3558 cal BC (9.2%)* *3538-3329 cal BC (80.8%)* *3216-3180 cal BC (2.9%)* *3158-3123 cal BC (2.6%)*	*3516-3397 cal BC (55.8%)* *3385-3358 cal BC (12.4%)*
GrA-1709	*Burial 4*	*Right scapula*	*4840±60*	*3766-3515 cal BC (93.5%)* *3422-3419 cal BC (0.2%)* *3410-3404 cal BC (0.4%)* *3398-3384 cal BC (1.3%)*	*3696-3628 cal BC (39.8%)* *3584-3532 cal BC (28.4%)*
Kilgreany Cave, County Waterford					
BM-135	*C.7* *Burial A*	*Human Rib Bone*	*4660±75*	*3640-3326 cal BC (89.4%)* *3230-3225 cal BC (0.2%)* *3220-3174 cal BC (3.1%)* *3160-3119 cal BC (2.7%)*	*3622-3606 cal BC (4.5%)* *3522-3362 cal BC (63.7%)*
Pta-2644	*C.9 Burial B*	*Human Skull*	*4820±60*	*3710-3500 cal BC (88.9%)* *3432-3379 cal BC (6.5%)*	*3661-3622 cal BC (22.3%)* *3605-3523 cal BC (45.9%)*
GrA-21499	*Burial 3*	*Mandible*	*4790±50*	*3658-3500 cal BC (86.0%)* *3432-3379 cal BC (9.4%)*	*3641-3624 cal BC (11.6%)* *3602-3524 cal BC (56.6%)*
Lough Gur, County Limerick					
GrN-16825	*Site 10*	*Human Bone*	*4740 ± 60*	*3641-3488 cal BC (63.3%)* *3471-3372 cal BC (32.1%)*	*3633-3554 cal BC (36.7%)* *3540-3509 cal BC (13.7%)* *3426-3382 cal BC (17.8%)*
Newtown (Carrigdirty Rock site 5), County Limerick					
Beta-102086	*Human skull*	*Frontal-parietal bone*	*4710±60*	*3634-3549 cal BC (29.9%)* *3544-3370 cal BC (65.5%)*	*3628-3584 cal BC (17.9%)* *3531-3496 cal BC (14.8%)* *3460-3376 cal BC (35.5%)*
GrA-27217		*Human Clavicle*	*4775±40*	*3646-3509 cal BC (87.1%)* *3426-3382 cal BC (8.3%)*	*3636-3626 cal BC (8.2%)* *3599-3526 cal BC (60.0%)*
GrA-27232		*Human Skull fragment*	*4770±40*	*3644-3507 cal BC (85.5%)* *3427-3381 cal BC (9.9%)*	*3636-3623 cal BC (9.2%)* *3604- 3524 cal BC (59.0%)*

Table 4.3 Calibrated radiocarbon dates for Burials

4.4.6. Fish-traps/field systems/trackways.

A further aspect of the Neolithic which must be considered is the dates for field systems, trackways and fish-traps from the region. Four radiocarbon dates (see Table 4.4) from three sites, Castleblagh (Claidh Dubh), County Cork (Doody 1995; 2008, 513-537) (For a full site description see Appendix B-24), Newtown (Carrigdirty Rock site 5), County Limerick (O'Sullivan 2001, 73-86) (For a full site description see Appendix B-64) and Cool West, County Kerry (Mitchell 1989) (For a full site description see Appendix B-26) are under consideration here. As *UB-3722,* from Castleblagh (Claidh Dubh), was returned from the peaty matrix into which the stone trackway had been set, the reliability of this date is questionable. To ensure the resulting models are robust it was decided to exclude this radiocarbon date from the model as it is impossible to determine if the date accurately reflects the date for construction of the monument.

For this same reason the radiocarbon date from Cool West has also been excluded from the model. The two dates from Newtown (Carrigdirty Rock site 5), County Limerick date the fish-basket directly and are therefore included in the model. The model defined in Figure 4.33 shows good overall agreement ($A_{overall}$=109.2) and suggests the start of activity in southern Ireland began in *4590 – 3530 cal BC (95% probability), 3790 – 3540 cal BC (68% probability)*. The resulting Bayesian model exhibited a rather large *posterior density estimate* for the construction of fish-traps. The long tails on the *posterior density estimate* arises as the model contains insufficient data to effectively assess and counteract the statistical scatter of radiocarbon dates. (For full model specifications see Appendix C.1.4.)

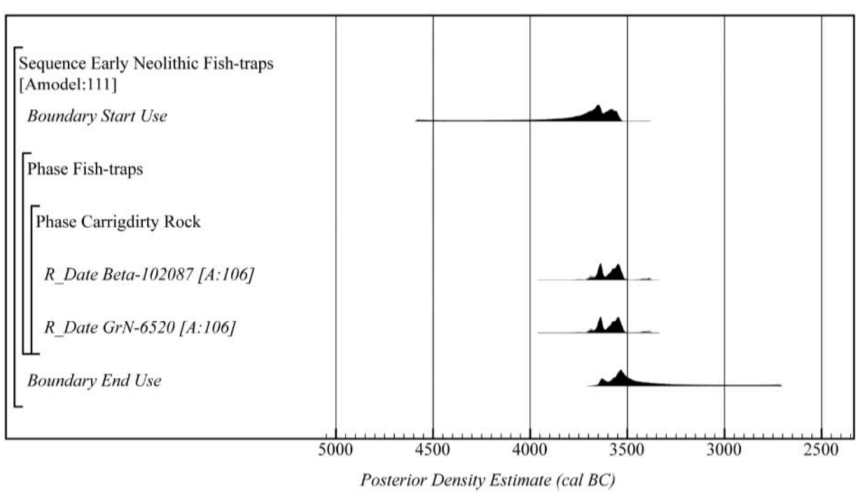

Figure 4.33 Bayesian model for Early Neolithic fish-traps in southern Ireland

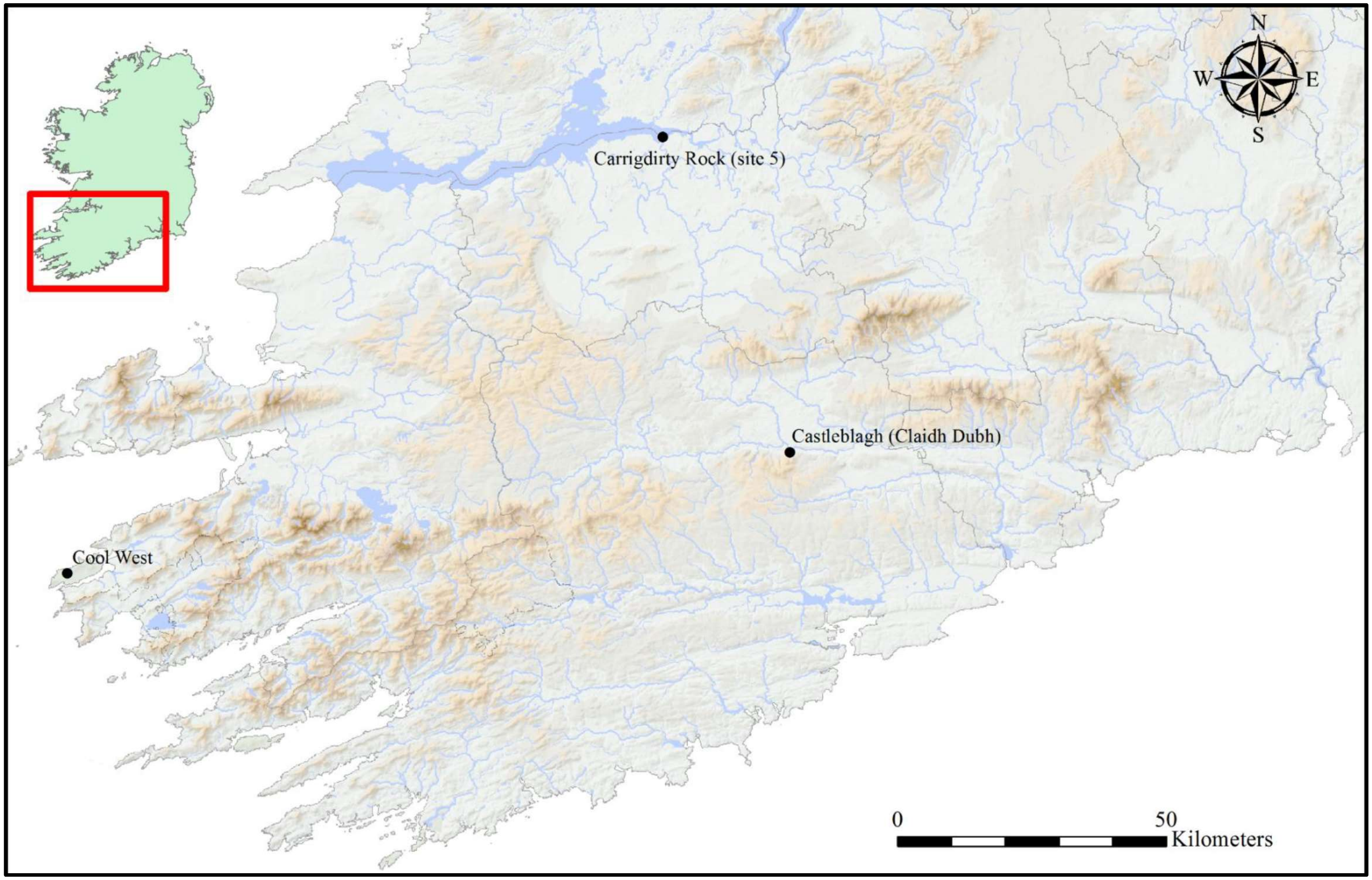

Figure 4.34 Early Neolithic fish-traps/field systems and trackways in southern Ireland

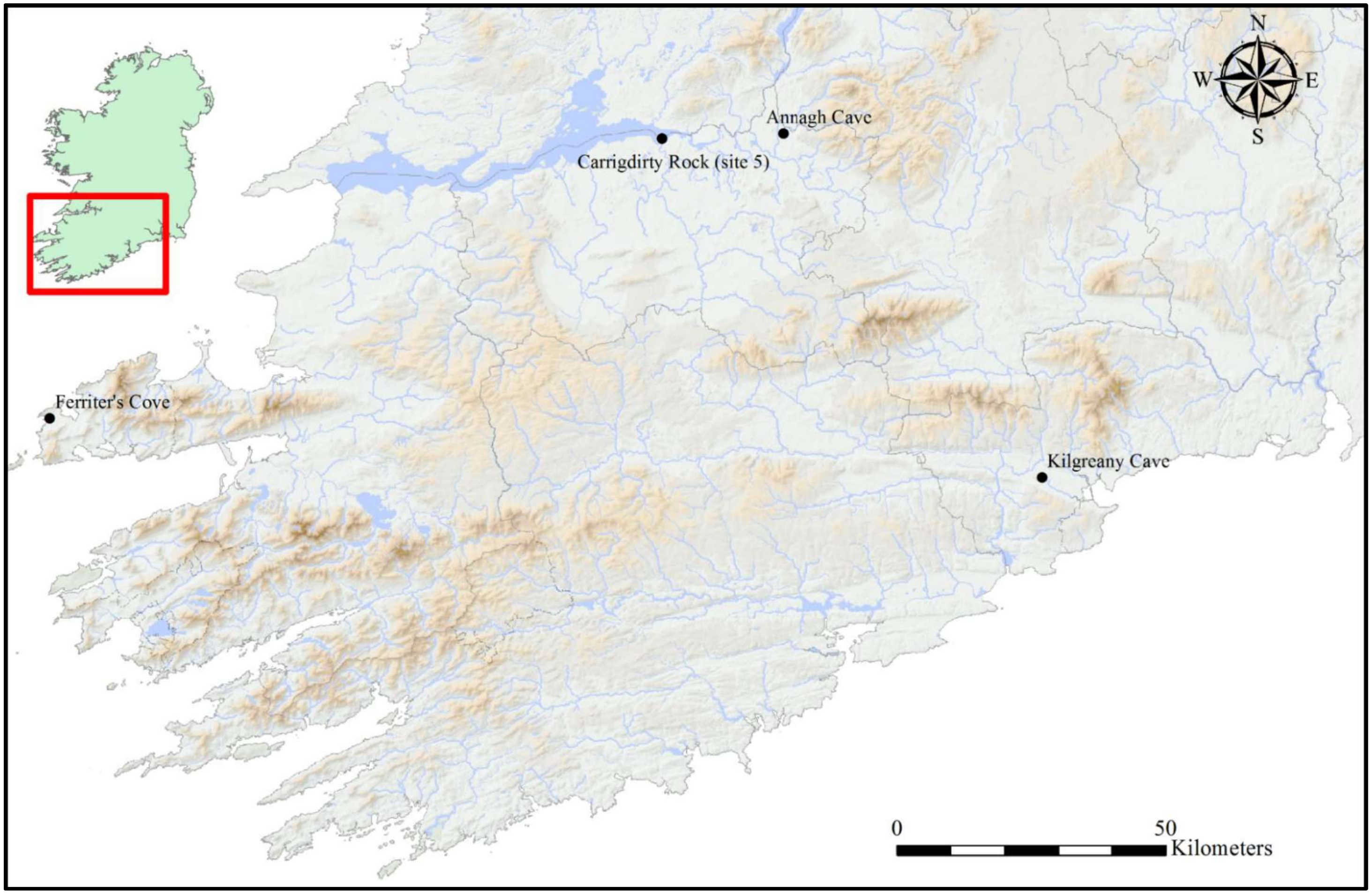

Figure 4.35 Sites with early domesticates from southern Ireland

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Castleblagh (Claidh Dubh), County Cork					
UB-3722	*Peaty matrix*	*Peat*	*4991±41*	*3931-3858 cal BC (22.6%)* *3816-3661 cal BC (72.8%)*	*3895-3881 cal BC (6.0%)* *3800-3706 cal BC (62.2%)*
Cool West, County Kerry					
I-14206	*Base of wall*	*Willow twigs*	*4760±100*	*3771-3346 cal BC*	*3644-3498 cal BC (50.5%)* *3436-3378 cal BC (17.7%)*
Newtown (Carrigdirty Rock site 5), County Limerick					
GrN-6520 (replica of Beta-102087)	*Basket fragment*	*Waterlogged alder shoots*	*4820±50*	*3705-3516 cal BC (94.0%)* *3398-3384 cal BC (1.4%)*	*3656-3626 cal BC (22.0%)* *3594-3526 cal BC (46.2%)*
Beta-102087	*Basket fragment*	*Waterlogged alder shoots*	*4820±50*	*3705-3516 cal BC (94.0%)* *3398-3384 cal BC (1.4%)*	*3656-3626 cal BC (22.0%)* *3594-3526 cal BC (46.2%)*

Table 4.4 Calibrated radiocarbon dates for trackways/field systems/fish-traps

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Annagh Cave, County Limerick					
GrA-1706	*Burial 3*	*Sheep humerus*	*4750±60*	*3645-3492 cal BC (67%)* *3469-3373 cal BC (28.4%)*	*3635-3516 cal BC (60%)* *3422-3419 cal BC (1%)* *3409-3405 cal BC (1.4%)* *3398-3385 cal BC (5.8%)*
Ferriter's Cove, County Kerry					
OxA-3869		*Cattle tibia*	*5510 ± 70*	*4502-4232BC (95.2%)* *4188-4182BC (0.2%)*	*4448-4326BC (63.6%)* *4283-4272BC (4.6%)*
OxA-8775		*Charred cattle metatarsus*	*5825 ± 50*	*4792-4548BC (95.4%)*	*4766-4756BC (3.8%)* *4729-4310BC (64.4%)*
Kilgreany Cave, County Waterford					
OxA-4269	*C.8*	*Cattle tibia*	*5190 ± 80*	*4234-3892BC (81.3%)* *3884-3798BC (14.1%)*	*4224-4206BC (3.7%)* *4161-4130BC (6.7%)* *4071-3940BC (49.5%)* *3858-3816BC (8.2%)*
Newtown (Carrigdirty Rock site 5), County Limerick					
GrA-27216		*Cattle bone*	*4775±40*	*3646-3509 cal BC (87.1%)* *3426-3382 cal BC (8.3%)*	*3636-3626 cal BC (8.2%)* *3599-3526 cal BC (60.0%)*

Table 4.5 Calibrated radiocarbon dates for early domesticates

4.4.7. Cereal cultivation.

Two additional characteristics of the Neolithic which must be considered are the dates for the introduction of what can be described as diagnostic Early Neolithic material, namely cereal cultivation and domesticates. A striking change from the earlier Mesolithic period is the discovery of the remains of various flora and fauna not indigenous to the island. Wheat, barley, cattle and sheep/goat must have been introduced from elsewhere, whether through a series of waves of contact or through a single 'colonising' event from Britain or Atlantic France. The chronology of the introduction of this quintessential Early Neolithic material is now considered.

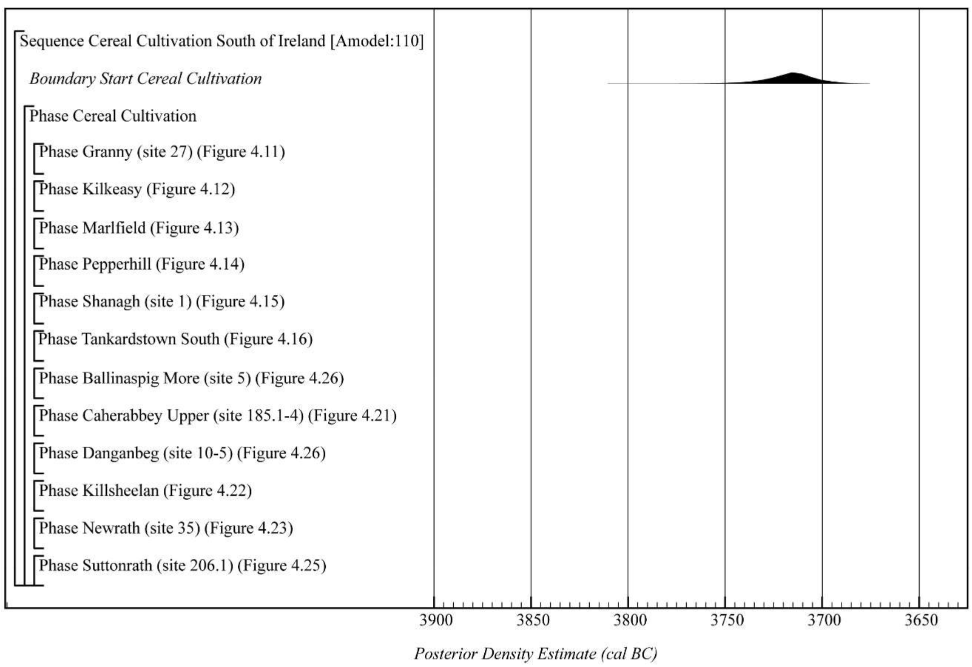

Figure 4.36 Bayesian model for start of cereal cultivation in southern Ireland

Thirty-nine radiocarbon determinations (see Table 4.1 & Table 4.2) from twelve sites are included in the model to refine the chronology for the commencement of cereal cultivation in the region. Twenty-four of which were from timber house structures at six sites with the remaining fourteen radiocarbon dates from six ephemeral occupation sites. The model shows good overall agreement ($A_{overall}$=109.3), the only outlier which shows poor agreement with the overall model is *UBA-14739*, from Tankardstown South, (A= 46.9%; (A'c)=60.0%). (For full model specifications see Appendix C.1.5.). The model defined in Figure 4.36 suggests that cereal cultivation in southern Ireland began in *3750 – 3690 cal BC (95% probability)* probably in *3730 – 3700 cal BC (68% probability)*.

4.4.8. Domesticates.

The next aspect of the Early Neolithic which needs to be considered is the date for the introduction of domesticates into the region. A cattle bone (*OxA-3869*) from Ferriter's Cove, County Kerry (Woodman *et al.* 1999), dated to the latter half of the 5th millennium cal BC, represents the earliest evidence for the presence of reportedly domesticated animals for the islands of Ireland and Britain (*ibid.*). Alternative suggestions of whether this represents an early phase of 'failed' colonisation (Sheridan 2010) or the remains of a joint of meat, from either wild or domesticated cattle, transported to Ireland from Britain or the Continent (Whittle 2007) have been proposed. Significantly, however, no further secure records of early, domesticated animal remains, that do not suffer from large age ranges, have been forthcoming (Milner 2010).

In total seven cattle bones and a single sheep tooth were recovered from the Late Mesolithic site of Ferriter's Cove, two of the cattle bones (*OxA-3869* and *OxA-8775*) have been dated to the *c.*4800 – 4500 cal BC. The suitability of the older of the two bone (*OxA-8775*) in Bayesian models which attempt to refine the chronology of the Early Neolithic was questioned by Cooney *et al.* (2011), as the date was obtained from charred bone which may have incorporated exogenous carbons of different age to itself (cf. Gillespie 1989). These two dates, in addition to the redeposited cattle tibia identified at Kilgreany Cave (*OxA-4269*) (Woodman *et al.* 1997; Dowd 2002), remain somewhat of an enigma in studies of the introduction of Neolithic agriculture into Ireland, being several centuries earlier than the more conclusive evidence of the 38th century cal BC. The inclusion or exclusion of radiocarbon dates from these are likely have serious implications on Bayesian models which attempt to establish a date range for the start of Neolithic practices in the region. These implications will be discussed in more detail later. Additional radiocarbon dates for domesticates are available from Annagh, County Limerick (Ó Floinn 1992; Dowd 2008; Ó Floinn 2011; Ó Donnabháin 2011) and Newtown (Carrigdirty Rock site 5), County Limerick (O'Sullivan 2001, 73-86; Woodman 2016, 16). A sheep humerus identified with Burial 3 from Annagh Cave and a cattle bone from Carrigdirty Rock (site 5) represent evidence for 37th century cal BC pastoral activity in the region (see Table 4.5).

The radiocarbon data for early domesticates demonstrated three distinct horizons, with the cattle bone from Ferriter's Cove earlier than that from Kilgreany Cave, which in turn appears to be earlier than the later 37th century examples from Carrigdirty Rock (site 5) and Annagh Cave. The model was therefore constructed with three sequential phases, Ferriter's Cove → Kilgreany Cave → Later Domesticates, with the dates from Carrigdirty Rock (site 5) and Annagh Cave treated as overlapping within the Later Domesticates sequence. The model defined in Figure 4.37 shows good overall agreement ($A_{overall}$=108.2) and suggests that domesticates appear in southern Ireland began in *4830 – 4090 cal BC (95% probability), 4520 – 4280 cal BC (68% probability)*. The resulting Bayesian model exhibited a rather large *posterior density estimate* for the introduction of domesticates in southern Ireland. The long tails on the *posterior density estimate* arises as the models contain insufficient data to effectively assess and counteract the statistical scatter of radiocarbon dates. (For full model specifications see Appendix C.1.6.).

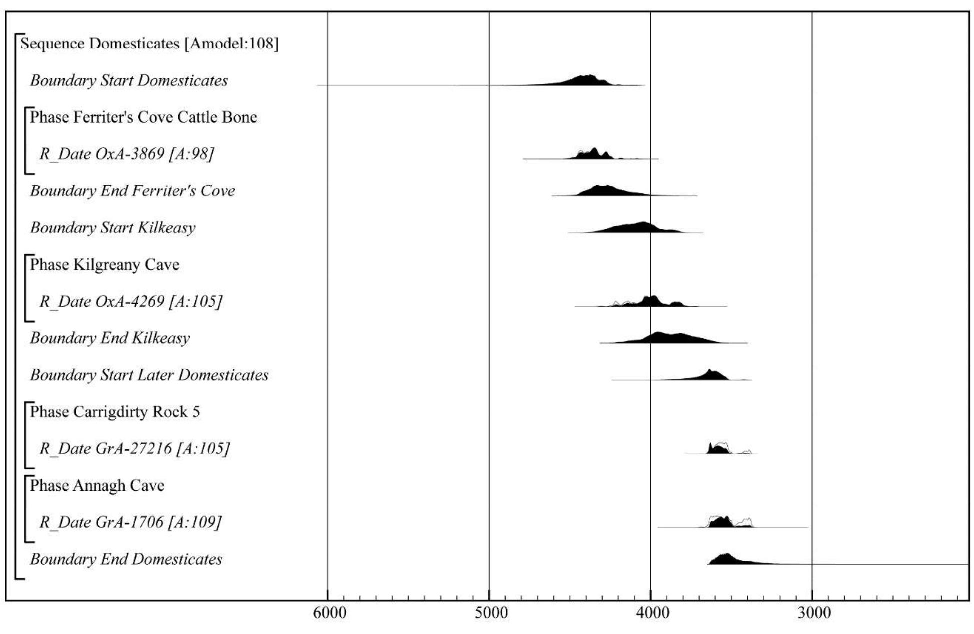

Figure 4.37 Bayesian model for early domesticates in southern Ireland

4.5. Dating the start of the Neolithic in in southern Ireland.

To provide a reliable estimate for the start of the Neolithic it is critical to impose a statistical distribution on the overall phase of activity sampled for Bayesian modelling. In the models proposed here a uniform distribution has been preferred (Buck *et al.* 1992; Ramsey 1995) to counteract the statistical scatter of radiocarbon dates (Steier and Rom 2000; Bronk Ramsey 2000; Cooney *et al.* 2011). If this scatter is not explicitly taken into account, models can be erroneously interpreted with start dates which may be too early or end dates which are too late (Bayliss *et al.* 2007) It is therefore essential to impose a statistical distribution on the dates of the period, with settlement sites associated with Early Neolithic Carinated Ware and early cereal cultivation defining the beginning of the Neolithic and in concurrence with the models proposed by Cooney *et al.* (2011) the dates for Linkardstown burials were treated as *termini ante quos* for the end of the Early Neolithic. In this study dates for passage tombs, as included by Cooney *et al.* (2011), were not included due to the lack of excavated examples in the region. The dates from two Linkardstown burials, Lisduggan North, County Cork (Cahill and Brindley 2011) (4585±80, *OxA-2681*) and Jerpoint West, County Kilkenny (Ryan 1973) (4770±80, *OxA-2680*), were included.

The models for the start of Neolithic activity presented here include the Bayesian modelled data from Early Neolithic houses, ephemeral sites, burials, fish-traps and domesticates in southern Ireland outlined above. The range could be said to represent much of the Early Neolithic in southern Ireland. Three separate models were tested, each model included the information above as defining the beginning of Neolithic activity (outline in **Sections 4.4.1.-4.4.6**.) with the dates for Linkardstown burials treated as *termini ante quos* for the end of the Early Neolithic. Due to the considerable time lapse between the date for early domesticates and the dates for Early Neolithic settlement and burials, the dates for domesticates were assessed in separate models to determine how these may affect the resulting models. In Model 1 all aspects of what could be defined as the Early Neolithic were treated as being one single phase, with each aspect deemed to have been introduced concurrently. In the second model house activity was treated as being the earliest expression of Early Neolithic activity with ephemeral sites, burials and fish-traps treated as following sequentially after the abandonment of house occupation. The third model again included all the radiocarbon data used in Models 1 and 2, in this model houses are again treated as the earliest manifestation of Early Neolithic practices, but are deemed to have overlapped with activity at ephemeral, burial and fish-trap sites. In none of these models was the Bayesian data for the commencement of cereal cultivation (outlined in **Section 4.4.7**) considered for inclusion, as all dates used in this model were also incorporated in the models outlined in **Sections 4.4.1-4.4.4.**

In Model 1, the Bayesian data from Early Neolithic houses, ephemeral sites, burials and fish-traps were compiled to propose a model for the introduction of Neolithic practices in southern Ireland. In this model all four site types are treated as having been introduced as one phase of Neolithisation (see Figure 4.38). In the first model the dates for domesticates at Ferriter's Cove, Annagh Cave, Carrigdirty Rock (site 5) and Kilgreany Cave were excluded the dates for Linkardstown burials were again treated as *termini ante quos* for the end of the Early Neolithic.

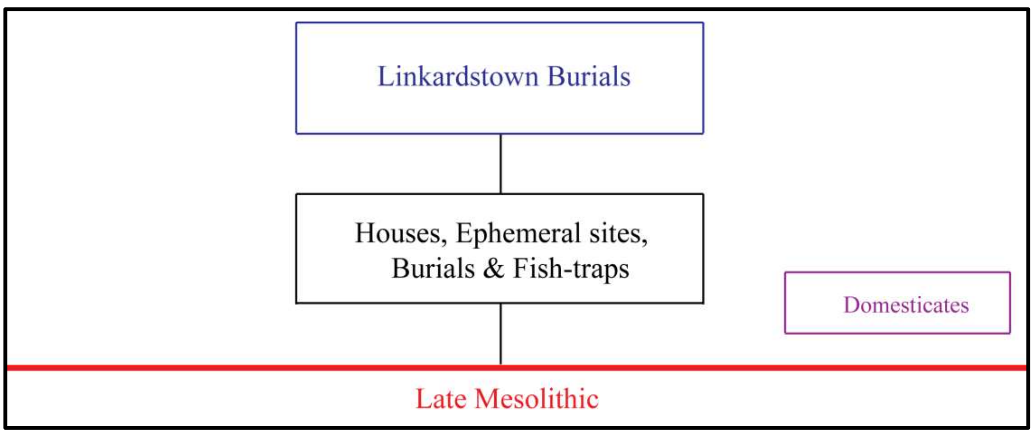

Figure 4.38 Structure of Model 1

A date range of *3740 – 3680 (95% probability), 3720 – 3690 cal BC (68% probability)* for the introduction of Neolithic practices was returned. Model 1 returned a date range of *3550 – 3510 cal BC (95% probability), 3550 – 3520 cal BC (68% probability)* for the end of the Early Neolithic in the region. This model showed good overall agreement ($A_{overall}$=108.9) with only *UBA-14739* from Tankardstown South (A=27.9%; (A'c)=60.0%) and *GrA-1708* from Annagh Cave (A=36.5%; (A'c)=60.0%) showing poor agreement with the overall model. Model 1 also proposed a duration of Early Neolithic activity in southern Ireland of between *130 – 200 years (95% probability), 150 – 190 years (68% probability)*. (For full model specifications see Appendix C.1.7.). When the dates for domesticates were included in this model a date range of *4020 – 3960 (95% probability), 4010 – 3970 cal BC (68% probability)* for the introduction of Neolithic practices was returned. Model 1a (with domesticates) returned a date range of *3540 – 3480 cal BC (95% probability), 3540 – 3500 cal BC (68% probability)* for the end of the Early Neolithic in the region. This model showed poor overall agreement ($A_{overall}$=46.8), however, with *OxA-3869* from Ferriter's Cove (A=0.0%; (A'c)=60.0%) showing particularly poor agreement with the overall model. Model 1a also proposed a duration of Early Neolithic activity in southern Ireland of between *430 – 510 years (95% probability), 440 – 490 years (68% probability)*. (For full model specifications see Appendix C.1.8.).

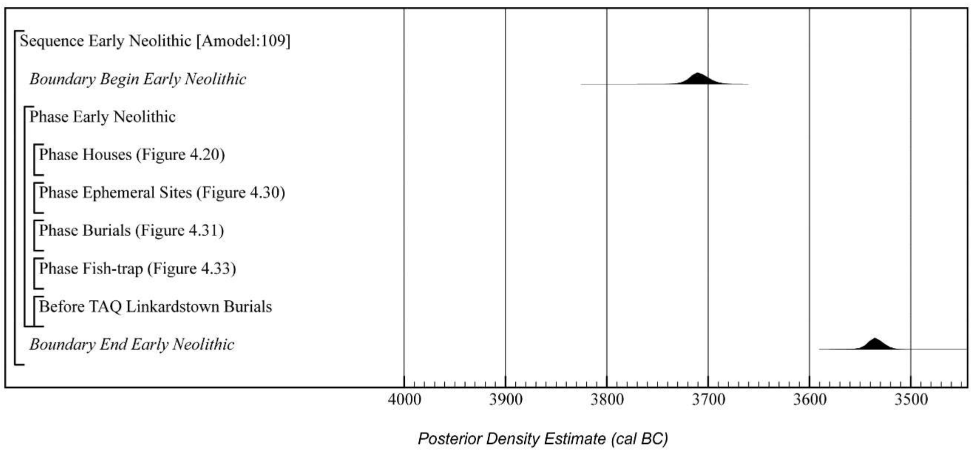

Figure 4.39 Bayesian modelled dates for the start and end on the Early Neolithic in southern Ireland (Model 1)

In Model 2, the Bayesian data from Early Neolithic houses used in Model 1, was again compiled with the dates for other forms of activity, which could be argued as belonging to the Early Neolithic to propose a model for the introduction of Neolithic practices in southern Ireland. However, in this model house sites were treated as the earliest manifestation of Early Neolithic practices in the region, with the ephemeral, burial and fish-trap sites deemed to have begun after the end of occupation at the house sites (see Figure 4.40). The interpretation that house sites represent the earliest Neolithic site type is supported by the statistical comparison of the *posterior density estimate* for the start of house occupation and the start of ephemeral and burial site occupation. Occupation of houses is 88.2% more probable to have occurred before occupation of ephemeral site and 98.1% more probable than burials (see Table 4.6). The percentage data for fish-traps is less clear, while the percentage data would suggest that the commencement at of these two site types was statistically more probable to have occurred concurrently, the long tail estimate for the start of fish-trap use skews the statistical relationship between the start of both of these site types. It is therefore impossible to categorically state whether activity at house sites pre-dated the use of fish-traps, although the individual radiocarbon determinations from each site would suggest that they do.

Probability t1<t2				
t2	Start House Occupation	Start Ephemeral Site Use	Start Burials	Start Fish-trap Use
t1				
Start House Occupation	0	88.23	98.18	51.79
Start Ephemeral Site Occupation	11.77	0	94.91	43.63
Start Burials	1.82	5.08	0	21.47
Start Fish-trap Use	48.21	56.37	78.53	0

Table 4.6 Statistical probability of 'event' order for the start of activity at each site type, calculated using Order() command in OxCal.

As in the first model, the dates for domesticates at Ferriter's Cove, Annagh Cave, Carrigdirty Rock (site 5) and Kilgreany Cave were excluded and the dates for Linkardstown burials were again treated as *termini ante quos* for the end of the Early Neolithic. Model 2 proposed a date range of *3720 – 3660 (95% probability), 3710 – 3660 cal BC (68% probability)* for the introduction of Neolithic practices and a date range of *3640 – 3520 cal BC (95% probability), 3640 – 3530 cal BC (68% probability)* for the end of the Early Neolithic. Model 2 also proposed a duration of Early Neolithic activity in southern Ireland of between *20 – 200 years (95% probability), 30 – 180 years (68% probability)*. (For full model specifications see Appendix C.1.9.).

This model showed poor overall agreement ($A_{overall}$=42.5) with *UBA-14793* (A= 53.9%; (A'c)= 60.0%) from Marlfield, *UBA-14739* (A= 8.3%; (A'c)= 60.0%) and *UBA-14737* (A= 55.4%; (A'c)= 60.0%) from Tankardstown South, *UBA-14408* (A= 44.1%; (A'c)= 60.0%), *UBA-14409* (A= 53.9%; (A'c)= 60.0%) and *UBA-14406* (A= 52.1%; (A'c)= 60.0%) from Caherabbey Upper (site 185.1-4), *UBA-14799* (A= 53.2%; (A'c)= 60.0%) from Newrath (site 35), *Poz-26554* (A= 0.3%; (A'c)= 60.0%) and *UBA-13996* (A= 29.8%; (A'c)= 60.0%) from Scart, *UB-7208* (A= 55.9%; (A'c)= 60.0%) from Suttonrath (site 206.1), *GrA-1703* (A= 39.2%; (A'c)= 60.0%) and *GrA-1708* (A= 12.1%; (A'c)= 60.0%) from Annagh Cave and *BM-135* (A= 39.5%; (A'c)= 60.0%) from Kilgreany Cave all showing poor agreement with the overall model.

When the dates for domesticates were included in this model date range of *4090 – 3960 (95% probability), 4030-3980 cal BC (68% probability)* for the introduction of Neolithic practices and a date range of *3560 – 3520 cal BC (95% probability), 3550 – 3530 cal BC (68% probability)* for the end of the Early Neolithic. This model showed poor overall agreement ($A_{overall}$=4.2), however, with *OxA-3869* from Ferriter's Cove in particular showing poor agreement with the overall model (A=0.3%; (A'c)=60.0%). Model 2a (with domesticates) also proposed a duration of Early Neolithic activity in southern Ireland of between *420 – 560 years (95% probability), 440 – 490 years (68% probability)*. (For full model specifications see Appendix C.1.10.).

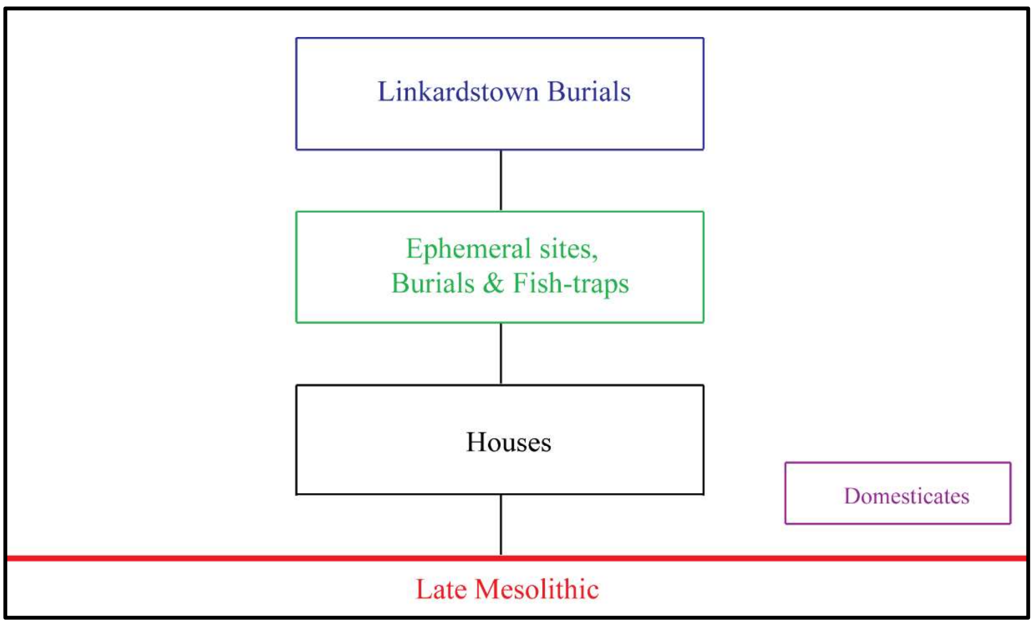

Figure 4.40 Structure of Model 2

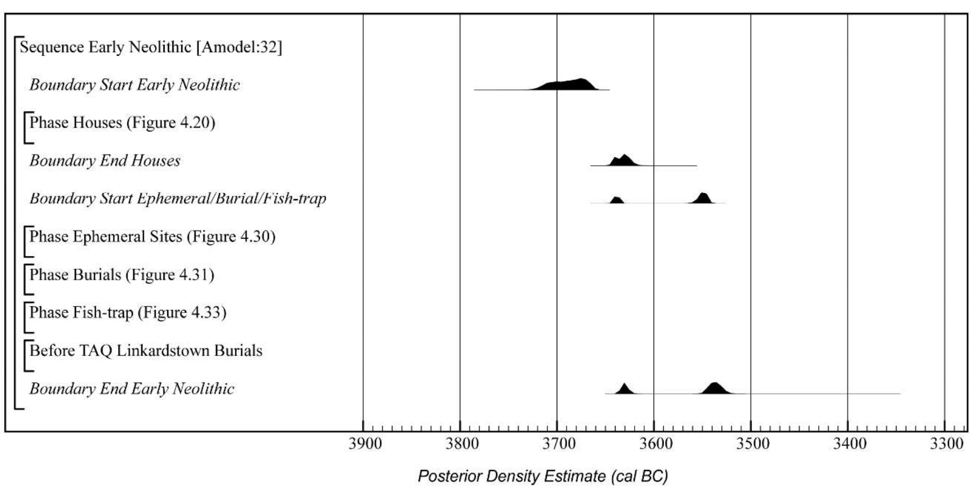

Figure 4.41 Bayesian modelled dates for the start and end on the Early Neolithic in southern Ireland (Model 2)

The low overall agreement of Model 2, and in particular the number of site which show poor agreement with the overall model suggests that the structure of the model is likely to be incorrect. The model treats the occupation of Early Neolithic houses as having ceased prior to commencement of the ephemeral sites, however, the model demonstrates that this interpretation is erroneous. Indeed, a statistical comparison of the *posterior density estimate* for the end of house occupation and the start of ephemeral site occupation would suggest a 99.9% probability that occupation of ephemeral sites commenced prior to the abandonment of Early Neolithic house sites in the region (see Table 4.7).

Probability t1<t2				
t2	End House Occupation	Start Ephemeral Site Use	Start Burials	Star Fish-trap Use
t1				
End House Occupation	0	0.02	67.90	26.45
Start Ephemeral Site Occupation	99.98	0	94.96	43.66
Start Burials	32.10	5.04	0	21.77
Start Fish-trap Use	73.55	56.34	78.24	0

Table 4.7 Statistical probability of 'event' order for the end of occupation of house sites and the beginning of activity at ephemeral, burial and fish-trap sites, calculated using Order() command in OxCal.

With this in mind a further model (3) was proposed to refine the date range for the introduction of Neolithic practices in the region. Model 3 again included the Bayesian data from Early Neolithic houses, ephemeral and other Early Neolithic sites as defining the beginning of Neolithic activity, with the dates for Linkardstown burials treated as *termini ante quos* for the end of the Early Neolithic. While the house sites were again treated as the earliest expression of the Early Neolithic, the ephemeral, burial and fish-trap sites were deemed to have overlapped in usage with the house sites (see Figure 4.42). As with the previous models the dates for domesticates at Ferriter's Cove, Annagh Cave, Carrigdirty Rock (site 5) and Kilgreany Cave were excluded from the model.

Model 3 returned a date range of *3760 – 3660 cal BC (95% probability), 3710 – 3670 cal BC (68% probability)* for the introduction of Neolithic practices and a date range of *3640 – 3480 cal BC (95% probability), 3630 – 3560 cal BC (68% probability)* for the end of the Early Neolithic in the region. (For full model specifications see Appendix C.1.11.). Model 3 also proposed a duration of Early Neolithic activity in southern Ireland of between *30 – 180 years (95% probability), 40 – 110 years (68% probability)*. This model showed good overall agreement ($A_{overall}$=94.6) with *UBA-14739* (A= 8.3%; (A'c)=

60.0%) and *UBA-14737* (A= 55.4%; (A'c)= 60.0%) from Tankardstown South, *Beta-201069* (A= 47.1%; (A'c)= 60.0%) from Curraghprevin (site 3), *Poz-26554* (A= 0.3%; (A'c)= 60.0%) from Scart and *GrA-1708* (A= 12.1%; (A'c)= 60.0%) from Annagh Cave all showing poor agreement with the overall model.

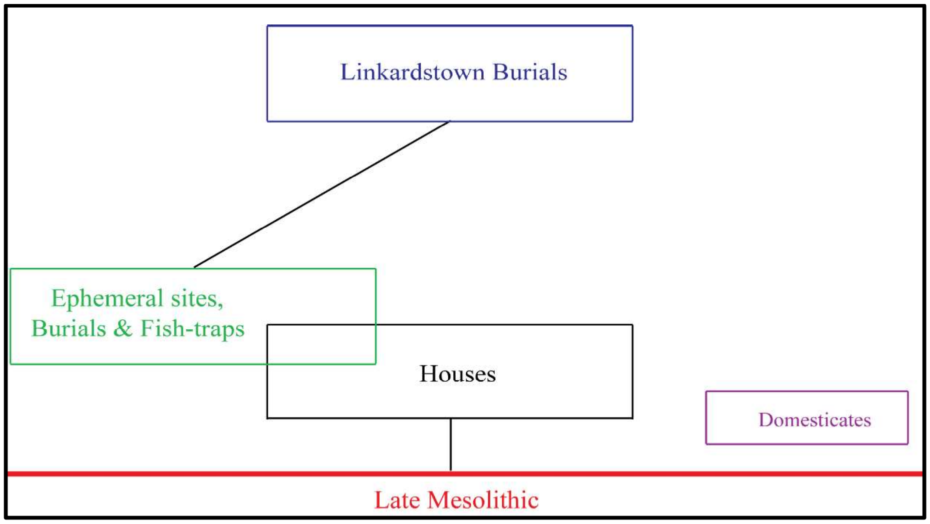

Figure 4.42 Structure of Model 3

When the dates for domesticates were included in this model date range of *4710 – 4060 (95% probability), 4430 – 4080 cal BC (68% probability)* for the introduction of Neolithic practices in the region and a date range of *3550 – 2960 cal BC (95% probability), 3530 – 3320 cal BC (68% probability)* for the end of the Early Neolithic. The long tails on the *posterior density estimate* arise as the model contains insufficient data for early domesticates to effectively assess and counteract the statistical scatter of radiocarbon dates. Model 3a (with domesticates) also proposed a duration of Early Neolithic activity in southern Ireland of between *490 – 1180 years (95% probability), 540 – 880 years (68% probability)*. (For full model specifications see Appendix C.1.12.). This model showed good overall agreement ($A_{overall}$=71.1), however, both *OxA-3869* from Ferriter's Cove (A=36.7%; (A'c)=60.0%) and *OxA-4269* from Kilgreany Cave (A=49.3%; (A'c)=60.0%) demonstrated poor agreement with the overall model. This would suggest that despite an acceptable level for the overall agreement, the model is likely to be erroneous as neither radiocarbon date range for early domesticates is in good agreement with the overall model.

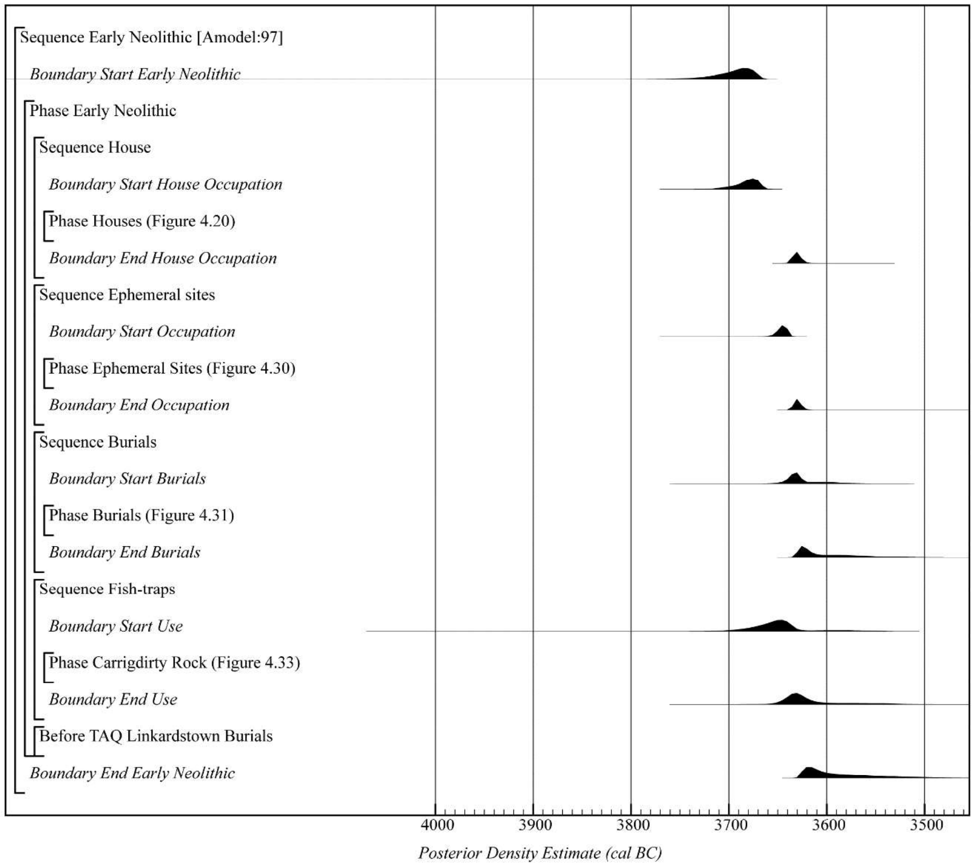

Figure 4.43 Bayesian modelled dates for the start and end on the Early Neolithic in southern Ireland (Model 3)

In the models proposed here, components relating to rectangular houses, ephemeral occupation evidence and other activities associated with diagnostically Early Neolithic material show generally good overall agreement (Models 1 and 3). However, in Model 2, which operated under the assumption that the occupation of Early Neolithic houses had ceased prior to the occupation of less well-defined ephemeral settlement sites, the model showed poor overall agreement and a statistical comparison of the *posterior density estimate* ranges for the end of activity at house sites and the start of occupation of ephemeral sites demonstrated that these two site types are likely to have overlapped. In Model 1, where each site type is hypothesised to have occurred concurrently, the overall agreement for the model is good. However, as has been outlined above, statistical analysis of the *posterior density estimate* ranges suggests that this may be an oversimplification of the process of Neolithisation. The grouping of these sites into one phase may have failed to counteract the statistical scatter of radiocarbon dates, which may have resulted in a start date range for the Early Neolithic which is a few decades too late. Therefore, Model 3, which treated each site type as having overlapped in usage, but still treating the house sites as having been the earliest manifestation of Neolithic practices possibly represents the most appropriate model for the start of the Neolithic in the region.

In all three models, when the radiocarbon determinations from early domesticates were included, overall agreement was considerably lower. This would suggest that the dates for domesticates from Ferriter's Cove (*OxA-3869*) and Kilgreany Cave (*OxA-4269*) are demonstratively different from the wider set of dates for Early Neolithic activity elsewhere in the region. The implications of which are that either these represent outliers within the chronological framework for the introduction of Neolithic practices in the region or a considerable temporal divergence exists between the introduction of domesticates and the introduction of the remaining elements of the Neolithic package, namely cereal cultivation and house construction. Questions remain on whether the presence of domesticates without other diagnostically Early Neolithic material can be used to define the commencement of Neolithic practices in the region (cf. Cooney *et al,* 2011). However, the presence of the early domesticates, suggests that domesticated fauna may have reached Ireland in some form or another sporadically for some centuries before the introduction of other Neolithic practices.

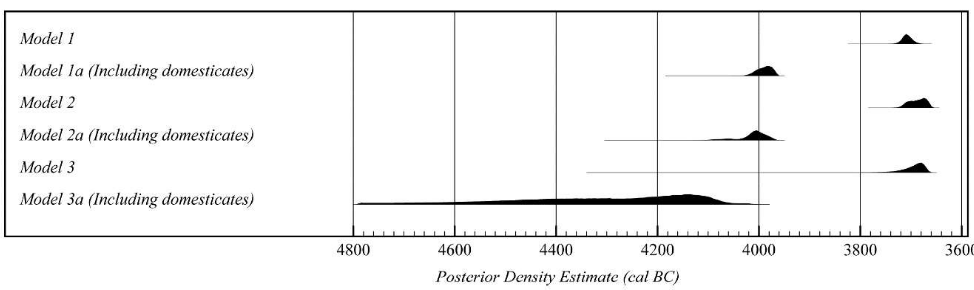

Figure 4.44 Start of the Neolithic in southern Ireland, Posterior density estimates derived from Models 1,2 & 3

The models (1 and 3) suggested here are comparable to the results for Model 2 by Cooney *et al.* (2011) where a similar date range, of *3750 – 3680 cal BC (95% probability), 3730 – 3695 cal BC (68% probability)*, for the start of the Neolithic was suggested. Also in agreement with the above models, Cooney *et al.*'s (2011) Model 2 showed poor overall agreement ($A_{overall}$=57.1%), when the cattle bone from Ferriter's Cove (*OxA-3869*) (A=0.5%; (A'c)=60.0%) was included. It is therefore obvious that the results of the models presented here and that of Cooney *et al.* (2011) are highly susceptible to the inclusion or exclusion of the date on cattle bones from Ferriter's Cove (*OxA-3869*) and Kilgreany Cave (*OxA-4269*), and can be said to be *'so radically different that either this single measurement must be appreciably inaccurate or the dated bone does not relate to wider processes of Neolithisation'* (Cooney *et al.* 2011, 663).

If Model 2 proposed by Cooney *et al.* (2011) is precise, then the Neolithic began quite rapidly with occupation sites associated with Early Neolithic material appearing within a generation before 3700 cal BC. This would appear to concur with the results of models proposed here, which would also suggest a rapid and abrupt transition to agriculture in southern Ireland from *c.*3750 cal BC. Although this does not exclude an earlier Neolithic presence, hints of which are found at Ferriter's Cove, Kilgreany Cave and in certain pollen records (e.g Lynch 1981; O'Connell and Molloy 2001). The nature of archaeological activity between the 'traditional' date for the start of the Neolithic, *c.*4000 cal BC and *c.*3750 cal BC, remains unclear however, due to chronological uncertainty and a lack of clarity as to the nature of settlement and agricultural activity, if any, at this time. The early cattle bones from Ferriter's Cove and Kilgreany Cave remain unusual in this context and questions whether these are isolated examples or part of some wider, as yet unidentified pre-3750 cal BC Neolithic activity. What is clear is that a boom in activity and expansion of settlement, with increases in the visibility of the archaeological record shown in the radiocarbon data, occurred across the region from the middle of the 38th century cal BC.

4.6. Conclusion.

While the three models outlined above suggest a mid to late 38th century cal BC start date for the Early Neolithic in southern Ireland, it is still unclear whether the models presented here reflect accurately the chronology for the Mesolithic/Neolithic transition. It must be a concern that the model is biased by a disproportionate number of radiocarbon determinations from timber houses, which provide more than 54% of dates for the uniform phase of Early Neolithic activity in all three models. This may over-estimate the scatter on the radiocarbon dates as a considerable amount of the data used here is from a restricted period within the whole of the Early Neolithic and thus the start date suggested in the models may be too late. The models also fail to definitively address the questions surrounding the dates for early domesticates from Ferriter's Cove and Kilgreany Cave.

While the models suggest a temporal separation between the occurrence of these early domesticates and what can be viewed as sites representative of Early Neolithic settlement and burial activity, it is still unclear whether these early domesticates represent outliers in the process of Neolithisation or a pre-38th century phase of selective adoption of Neolithic practices. A further limiting factor is the lack of a strong corpus of securely dated contexts from the preceding Late Mesolithic period (*c.*4500 – 4000/3750 cal BC), which could severely restrict our understanding of this transitionary period. Also, not incorporated into these models were the dated pollen sequences which have been undertaken as part of this study or the corpus of other dated pollen data from across the region. The inclusion of such, especially the radiocarbon dates for post-'Elm Decline' woodland clearance phases have proved to be highly informative in comparison to the models outlined above (see **Chapter 7**).

Chapter 5 - Palaeoenvironmental analysis from Lough Cullin, County Kilkenny.

5.1. Introduction.

While the previous two chapters have outlined and assessed the archaeological evidence for the early Neolithic in the region, the following two chapters outline the palaeoenvironmental evidence for woodland disturbance and anthropogenic activity during the Mesolithic/Neolithic transition. In this chapter the results from the palaeoecological investigations at Lough Cullin, County Kilkenny, in the south-east of the study region, are presented and the relationship between Holocene vegetation, the local environmental conditions, human impacts and regional vegetation changes are examined and interpreted. The chronology of palynological 'events' often associated with the adoption of Neolithic agriculture are outlined in this chapter but are considered in greater detail in **Chapter 7**, especially in relation to the archaeological evidence outlined in the previous chapters. Finally, the implications of this palaeoenvironmental analysis on the understanding of ecological change, woodland development and the timing and intensity of early Neolithic agriculture in the region are discussed in **Chapter 8**. For methodologies and site information see **Chapter 2**.

5.2. Results.

5.2.1. Stratigraphy.

The stratigraphy was recorded in the laboratory by Dr Susan Hegarty and only the section of the core analysed as part of this research is discussed here. The sediment largely consisted of a very dark, organic *gyttja* throughout, which appear to be slightly sandier between 594cm and 608cm. The sediment was less organic below 625cm, where it appeared to be much sandier with very poor pollen concentration. As concentration was so low in this section, the pollen profile under consideration here is from sub-samples taken between 625cm and 390cm.

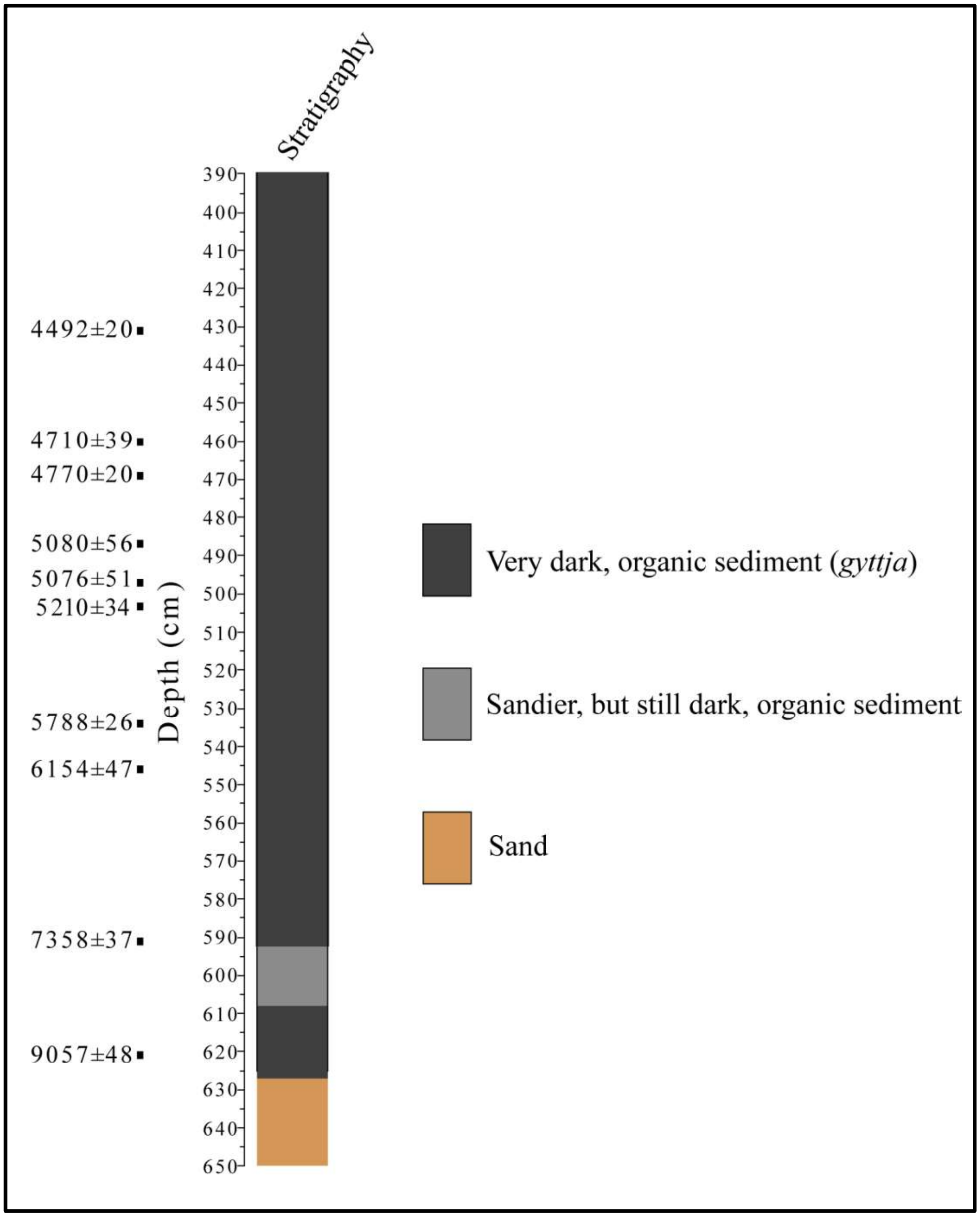

Figure 5.1 Stratigraphic record of palaeoenvironmental core from Lough Cullin (LC)

5.2.2. Chronology.

A total of thirteen radiocarbon measurements were obtained for this sequence (see Table 5.1). Six paired radiocarbon measurements were obtained on true replicates of different chemical fractions (humic acid and humin fractions) from three 1cm³ bulk peat samples (431cm, 469cm and 534cm) and an additional seven were obtained from humin fraction from a 1cm³ bulk peat sample. The statistical consistency of these six paired radiocarbon measurements was assessed (see Table 5.2), with only the paired radiocarbon measurements *SUERC-70843* and *SUERC-70844*, from a depth of 534cm, shown to be statistically inconsistent (T'=9.1; T'(5%)=3.8; v=1) (Ward and Wilson 1978) and are therefore estimated to not be coeval.

The age-depth model (not shown see Appendix C 3.1) had good overall agreement (A_{model}=95.1) when all measurements were included but given the statistical inconsistency from the paired radiocarbon measurements from 534cm, the humic measurement has been excluded. Humic acids are water-soluble and therefore are potentially able to move up or down through the profile, which may have caused the resulting humin and humic fraction radiocarbon determinations not to be coetaneous (Brock *et al.* 2011, 552). The age-depth model (Bronk Ramsey 2008; Bronk Ramsey and Lee 2013) is therefore constructed using the combined measurements from 431cm and 469cm, with the humin fraction measurements from 460cm, 487cm, 497cm, 501cm, 534cm, 546cm, 591cm and 621cm. This age depth model has good overall agreement (A_{model}=94.4) and is believed to be robust (For model specifications see Appendix C 3.2). Analysis of all dates incorporated into the model determined that no outlier existed (see Appendix C 3.3)

This age-depth model has been used to calculate deposition rates for the profile, provide a *posterior density estimate* for pollen assemblage zones and palynological features from the profile such as the mid-Holocene 'Elm Decline', the initiation of the *Plantago* curve and the beginning of cereal cultivation (see Table 5.3). The sequence is estimated to cover *5760 – 6520 years* (*95.4% probability* distribution not shown) covering much of the Holocene from the Early Mesolithic to the Chalcolithic/Early Bronze Age. Estimates derived from the age-depth model suggest an average accumulation rate of *3 – 5cm/100 years* (*95.4% probability*) between the upper and basal radiocarbon measurements or alternatively *23 – 26 years* (*95.4% probability*) are represented in every centimetre. (For *P_Sequence* deposition model specifications see Appendix C 3.4).

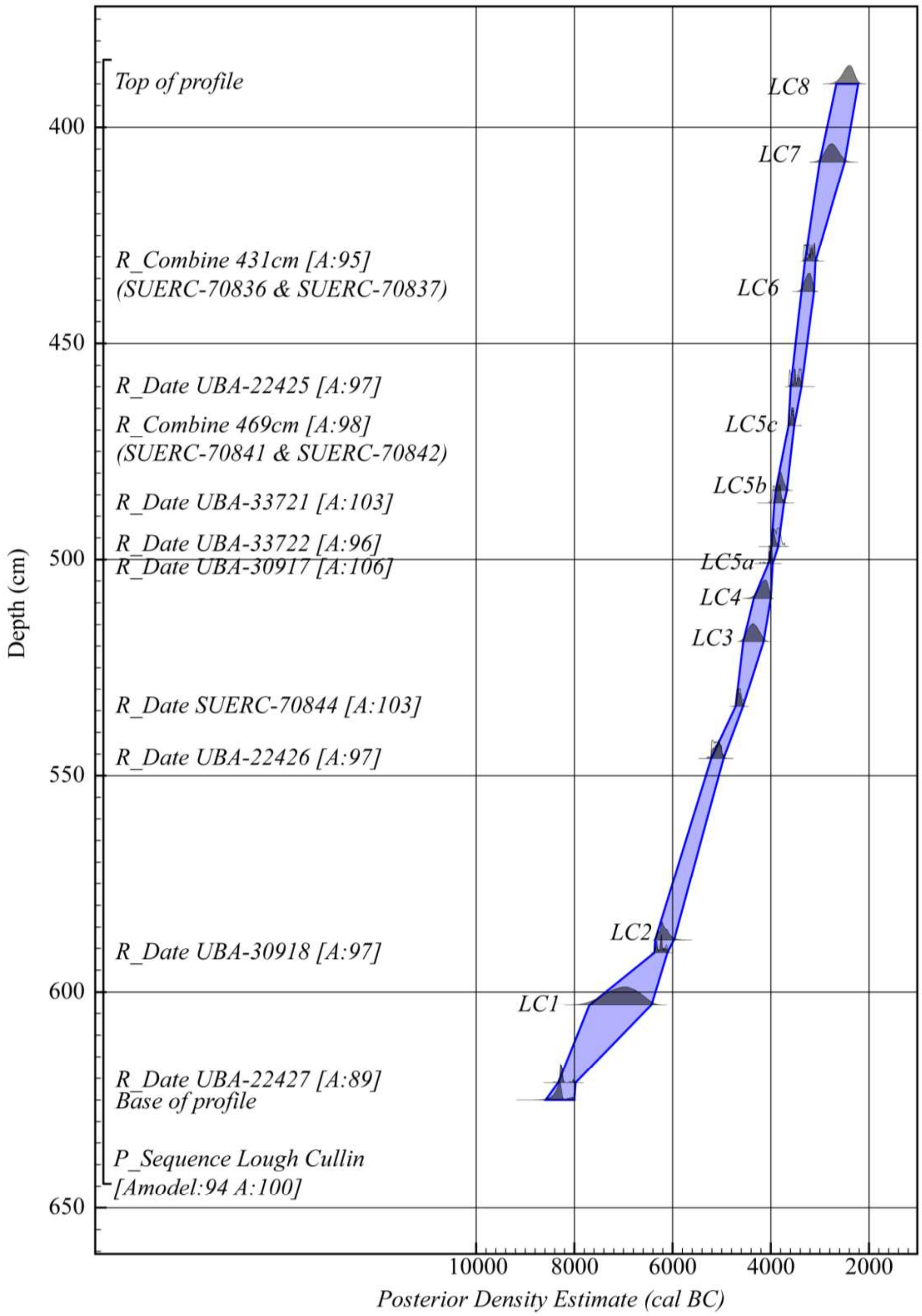

Figure 5.2 Bayesian age-model of the chronology of the sediment sequence at Lough Cullin (P_Sequence model (k=0.01 – 100) (Bronk Ramsey 2008; Bronk Ramsey and Lee 2013) Blue band showing the estimated date of sediment at the corresponding depth at 95.4% probability

Lab Code	Depth (cm)	Dated Material	Radiocarbon Age (years BP)	Calibrated Age (2δ) 95.4% Probability	Calibrated Age (1δ) 68.2% Probability
SUERC-70836	430 – 432	Peat (humic fraction)	4459±29	3336 – 3210 cal BC (48.2%) 3193 – 3151 cal BC (10.1%) 3139 – 3021 cal BC (37.2%)	3323 – 3234 cal BC (39.0%) 3172 – 3162 cal BC (3.4%) 3117 – 3086 cal BC (13.3%) 3061 – 3030 cal BC (12.4%)
SUERC-70837	430 – 432	Peat (humin fraction)	4520±27	3354 – 3264 cal BC (31.3%) 3242 – 3103 cal BC (64.1%)	3349 – 3323 cal BC (13.2%) 3234 – 3171 cal BC (31.1%) 3163 – 3116 cal BC (23.9%)
UBA-22425	459 – 461	Peat (humin fraction)	4710±39	3633 – 3558 cal BC (27.5%) 3538 – 3489 cal BC (21.1%) 3471 – 3373 cal BC (46.8%)	3627 – 3595 cal BC (16.9%) 3527 – 3498 cal BC (16.3%) 3437 – 3378 cal BC (35.0%)
SUERC-70841	468 – 470	Peat (humic fraction)	4755±29	3638 – 3513 cal BC (86.2%) 3423 – 3383 cal BC (9.2%)	3633 – 3619 cal BC (10.2%) 3611 – 3556 cal BC (43.7%) 3539 – 3521 cal BC (14.3%)
SUERC-70842	468 – 470	Peat (humin fraction)	4795±26	3644 – 3623 cal BC (17.2%) 3602 – 3524 cal BC (78.2%)	3638 – 3631 cal BC (10.1%) 3579 – 3535 cal BC (58.1%)
UBA-33721	486 – 488	Peat (humin fraction)	5080±56	3979 – 3760 cal BC (92.5%) 3742 – 3714 cal BC (2.9%)	3956 – 3906 cal BC (25.3%) 3880 – 3801 cal BC (42.9%)
UBA-33722	496 – 498	Peat (humin fraction)	5076±51	3975 – 3761 cal BC (93.6%) 3740 – 3731 cal BC (0.7%) 3725 – 3715 cal BC (1.0%)	3953 – 3907 cal BC (24.0%) 3880 – 3801 cal BC (44.2%)
UBA-30917	500 – 502	Peat (humin fraction)	5210±34	4221 – 4211 cal BC (1.2%) 4154 – 4133 cal BC (2.8%) 4064 – 3958 cal BC (91.4%)	4041 – 4011 cal BC (34.9%) 4005 – 3976 cal BC (33.3%)
SUERC-70843	533 – 535	Peat (humic fraction)	5675±27	4578 – 4572 cal BC (0.6%) 4560 – 4452 cal BC (94.8%)	4533 – 4486 cal BC (57.1%) 4476 – 4466 cal BC (11.1%)
SUERC-70844	533 – 535	Peat (humin fraction)	5788±26	4710 – 4555 cal BC	4691 – 4605 cal BC
UBA-22426	545 – 547	Peat (humin fraction)	6154±47	5221 – 4961 cal BC	5207 – 5090 cal BC (51.7%) 5083 – 5048 cal BC (16.5%)
UBA-30918	590 – 592	Peat (humin fraction)	7358±37	6360 – 6288 cal BC (18.4%) 6273 – 6091 cal BC (77.0%)	6339 – 6314 cal BC (10.0%) 6258 – 6207 cal BC (39.8%) 6168 – 6161 cal BC (2.3%) 6142 – 6106 cal BC (16.1%)
UBA-22427	620 – 622	Peat (humin fraction)	9057±48	8422 – 8407 cal BC (0.7%) 8388 – 8384 cal BC (0.2%) 8348 – 8208 cal BC (94.5%)	8295 – 8248 cal BC

Table 5.1 Radiocarbon dates for core LC (Lough Cullin). Radiocarbon dates were calibrated using the datasets published by Reimer et al. (2013) and the computer program OxCal 4.3 (Bronk Ramsey 1995; 1998; 2001; 2009).

Lab Code	Depth (cm)	R_Date	R_Combine Date	T' Value	R_Combine Calibrated Age (2δ) 95.4% Probability	R_Combine Calibrated Age (1δ) 68.2% Probability
SUERC-70836	431	4459±29	4492±20	T'=2.4; T'(5%)=3.8; v=1	3339 – 3206 cal BC (56.8%) 3196 – 3097 cal BC (38.6%)	3330 – 3265 cal BC (32.7%) 3242 – 3215 cal BC (13.8%) 3182 – 3158 cal BC (12.0%) 3124 – 3105 cal BC (9.7%)
SUERC-70837	431	4520±27				
SUERC-70841	469	4755±29	4777±20	T'=1.1; T'(5%)=3.8; v=1	3639 – 3622 cal BC (12.8%) 3604 – 3523 cal BC (82.6%)	3634 – 3629 cal BC (5.5%) 3585 – 3531 cal BC (62.7%)
SUERC-70842	469	4795±26				
SUERC-70843	534	5675±27	5734±19	T'=9.1; T'(5%)=3.8; v=1	4680 – 4636 cal BC (10.6%) 4620 – 4516 cal BC (84.2%) 4509 – 4505 cal BC (0.6%)	4606 – 4541 cal BC
SUERC-70844	534	5788±26				

Table 5.2 Weighted mean using R_Combine() function in OxCal 4.3 (Bronk Ramsey 1995; 1998; 2001; 2009).

Parameter	Top Depth (cm)	Radiocarbon date/*P_Sequence* 2δ *Posterior Density Estimate (95.4%)* PAZ top	Radiocarbon date/*P_Sequence* 1δ *Posterior Density Estimate (68.2%)* PAZ top
Top of Profile/LC8	390	*2670 – 2210 cal BC*	*2530 – 2300 cal BC*
LC7	408	*3010 – 2490 cal BC*	*2890 – 2620 cal BC*
LC6	438	*3380 – 3120 cal BC*	*3310 – 3160 cal BC*
LC5c	469	*3640 – 3620 cal BC (17.0%)* *3610 – 3520 cal BC (78.4%)*	*3640 – 3620 cal BC (10.8%)* *3590 – 3530 cal BC (57.4%)*
LC5b	484	*3910 – 3670 cal BC*	*3860 – 3740 cal BC*
LC5a	501	*4050 – 3960 cal BC*	*4040 – 4010 cal BC (21.0%)* *4010 – 3970 cal BC (47.2%)*
LC4	509	*4350 – 4000 cal BC*	*4230 – 4040 cal BC*
LC3	519	*4560 – 4140 cal BC*	*4480 – 4240 cal BC*
LC2	588	*6360 – 5960 cal BC*	*6330 – 6280 cal BC (10.8%)* *6260 – 6090 cal BC (57.4%)*
LC1	603	*7700 – 6430 cal BC*	*7370 – 7350 cal BC (0.6%)* *7350 – 6660 cal BC (67.6%)*
Bottom of Profile	625	*8610 – 8210 cal BC (85.9%)* *8180 – 8000 cal BC (9.9%)*	*8430 – 8250 cal BC*

Table 5.3 Posterior Density Estimate for top & bottom of profile, PAZs, the mid-Holocene 'Elm Decline', Initiation of the Plantago curve and cereal cultivation from Lough Cullin (LC)

5.2.3. Pollen.

PAZ/Depth (cm)	PAZ top	Main pollen features
LC8 (390 – 408)	*2670 – 2210 cal BC*	Reduction in AP (57 to *c*.44%) values especially *Ulmus* (to 0%), while both *Quercus* (*c*.26 to 20%) and *Alnus* (to 21%) values are temporally reduced at the start of the PAZ. *Corylus* values fall from 38 to *c*.26% mid-way through the PAZ, *Pinus* disappears from the record, while *Betula* increases from *c*.2 to 6% towards the top of the PAZ. There is a further increase in NAP values to *c*.15%, with the initiation in a second continuous *Plantago lanceolata* curve (*c*.1 – *c*.3%). Poaceae values increase from *c*.3 to *c*.6%, while Apiaceae, *Rumex acetosa/acetosella,* Ranunculaceae, Asteraceae (Asteroideae/Cardueae) undif., *Filipendula* and *Potentilla*-type occur more frequently. *Cerealia*-type pollen again recorded in addition to *Artemisia,* Caryophyllaceae and *Plantago major/media.*
LC7 (408 – 438)	*3010 – 2490 cal BC*	A second reduction in *Ulmus* values from *c*.9 to 1% is evidenced at the start of the PAZ, with *Quercus* values also reduced from *c*.30 to 24%. *Corylus* increases from 33 to *c*.39%, while *Betula* (*c*.5%) and *Fraxinus* (*c*.2%) values remain relatively stable. *Alnus* also increases from *c*.15 to 28% throughout the PAZ and *Salix* (3 – *c*.6%) is present in greater values. There is an increase in NAP values from *c*.5 to *c*.10% mid-way through the PAZ with *Rumex acetosa/acetosella,* Ranunculaceae and *Artemisia* occurring more regularly. *Plantago lanceolata* is recorded sporadically and *Cerealia*-type pollen again recorded.

PAZ/Depth (cm)	PAZ top	Main pollen features
LC6 (438 – 469)	*3380 – 3120 cal BC*	AP values increased to *c.*70% and *Ulmus* values recover to *c.*10% at the start of the PAZ, a slightly increased representation of *Betula* (8%) and *Fraxinus* (7%) is exhibited, while *Pinus* has reduced to minimal levels. NAP values decline to 2% at the base of the PAZ and before recovering to *c.*7% by the top of the PAZ. The sporadic occurrence of *Plantago lanceolata, Filipendula* and Asteraceae (Asteroideae/Cardueae) undif. is recorded throughout the PAZ.
LC5c (469 – 484)	*3640 – 3520 cal BC*	AP values recover to *c.*66% from the start of the PAZ, especially *Quercus* (*c.*22%). *Alnus* (to *c.*34%) and *Betula* (to *c.*7%) increase, before *Alnus* values fall to 20% at the top of the PAZ. *Fraxinus* (*c.*3%) and *Ilex* (<1%) are present throughout and *Ulmus* values begin to recover from 1 to *c.*4%. NAP values are reduced to *c.*4% by the top of the PAZ, while *Taxus* appears in the profile for the first time. A continuous but reduced curve for *Plantago lanceolata* (1 – *c.*2%) and *Rumex acetosa/acetosella* (<1%) is still exhibited as is the occasional occurrence of *Urtica, Artemisia* and Ranunculaceae, while *Cerealia*-type pollen again recorded.

PAZ/Depth (cm)	PAZ top	Main pollen features
LC5b (484 – 501)	*3910 – 3670 cal BC*	AP (54 to *c.*44%), primarily *Quercus* (22 to *c.*14%), values are reduced. *Corylus* increases to *c.*42% at the start of the PAZ before decreasing to between 30 and 35% as the PAZ progresses. *Alnus* values remain stable (*c.*25%), while values of both *Pinus* (2 – 4%) and *Betula* (2 – 5%) remain low. The continuous presence of *Ilex* is interrupted. NAP values increase considerably to *c.*19%, especially Poaceae (*c.*10%), while a continuous presence of both *Plantago lanceolata* (*c.*3 – *c.*6%) and Ranunculaceae (*c.*1 – 2%) is exhibited. *Urtica*, *Filipendula, Potentilla*-type and Asteraceae (Asteroideae/Cardueae) undif. are present throughout the PAZ. *Cerealia*-type pollen again recorded in addition to *Artemisia* and *Plantago major/media.*
LC5a (501 – 509)	*4050 – 3960 cal BC*	*Ulmus* values decrease from 8 to *c.*3% the start of the PAZ while a temporary, reduction in *Corylus* from *c.*43 to *c.*28% also occurs. *Quercus* and *Alnus* values are increased slightly, while *Pinus* and *Betula* values remain low. *Fraxinus* and *Carpinus* appear are recorded for the first time. There is an increase in NAP values from *c.*3 to *c.*10% and the first *Cerealia*-type pollen recorded. Continuous Asteraceae (Asteroideae/Cardueae) undif. curve is present throughout the PAZ, while *Plantago lanceolata* occurs more regularly and Apiaceae is recorded for the first time.

PAZ/Depth (cm)	PAZ top	Main pollen features
LC4 (509 – 519)	*4350 – 4000 cal BC*	There is a decrease in *Ulmus* from *c.*13 to 5% before recovering to *c.*8% at the top of the PAZ. Increased values of both *Alnus* (*c.*20 to 27%) and *Corylus* (*c.*34 to *c.*41%) are exhibited, while *Quercus* also declines from *c.*24 to *c.*17% across the PAZ. *Pinus* and *Betula* are present, but values remain low and *Tilia* present for the first time. NAP values remain constant at 4 – 5%, with only the occasional record of *Plantago lanceolata*, *Filipendula,* Asteraceae (Asteroideae/Cardueae) undif., Asteraceae (Lactuceae) undif., *Rumex acetosa/acetosella* and Ranunculaceae recorded. *Artemisia* is present for the first time.
LC3 (519 – 588)	*4560 – 4140 cal BC*	*Corylus* values recover to 39% at the start of the PAZ, while *Betula* declines to 4% before recovering to *c.*8%. *Quercus* (*c.*17 %), *Pinus* (*c.*15%) and *Ulmus* (*c.*10%) remain relatively stable, before values of *Pinus* and *Betula* marginally, but steadily decline at the top of the PAZ. *Alnus* values continue to rise throughout, reaching *c.*25% by the top of the PAZ. The initiation of continuous *Ilex* curve is recorded at top of PAZ, NAP values increase marginally to 6% at the base and top of the PAZ, and the sporadic occurrence of *Plantago lanceolata, Urtica,* Caryophyllaceae, Asteraceae (Asteroideae/Cardueae) undif. and Asteraceae (Lactuceae) undif. is recorded.

PAZ/Depth (cm)	PAZ top	Main pollen features
LC2 (588 – 603)	*6360 – 5960 cal BC*	There is a temporary reduction in values of both *Corylus* (53 to 28%) and *Quercus* (*c.*13 to 7%) which corresponds with a temporary increase in *Betula* (4 to *c.*16%) and *Pinus* (*c.*3 to 22%). *Hedera* and *Salix* are again present throughout but *Hedera* values decline (from 2 to <1%) as the PAZ progresses. *Sambucus* and *Calluna vulgaris* appear in the profile for the first time, while *Alnus* expands at the top of PAZ from *c.*3 to 16%. NAP values increase marginally mid-way through the PAZ to *c.*6%, with *Rumex acetosa/acetosella* and Ranunculaceae recorded for the first time.
LC1 (603 – 625)	*7700 – 6430 cal BC*	High values of *Corylus* (*c.*55%), *Quercus* (*c.*30%) and *Ulmus* (*c.*5 – 8%) are exhibited throughout the PAZ, with lesser amounts of *Pinus* (*c.*3 – 6%), *Betula* (*c.*2 – 7%) and *Alnus* (<2%) also present. A continuous presence of *Hedera helix* and *Salix* is also exhibited. NAP values remain low at between 1 and *c.*3%, Poaceae values at less than 1.5%, while both Cyperaceae and *Filipendula* are sporadically recorded throughout the PAZ.

Table 5.4 Summary of pollen profile Lough Cullin (LC)

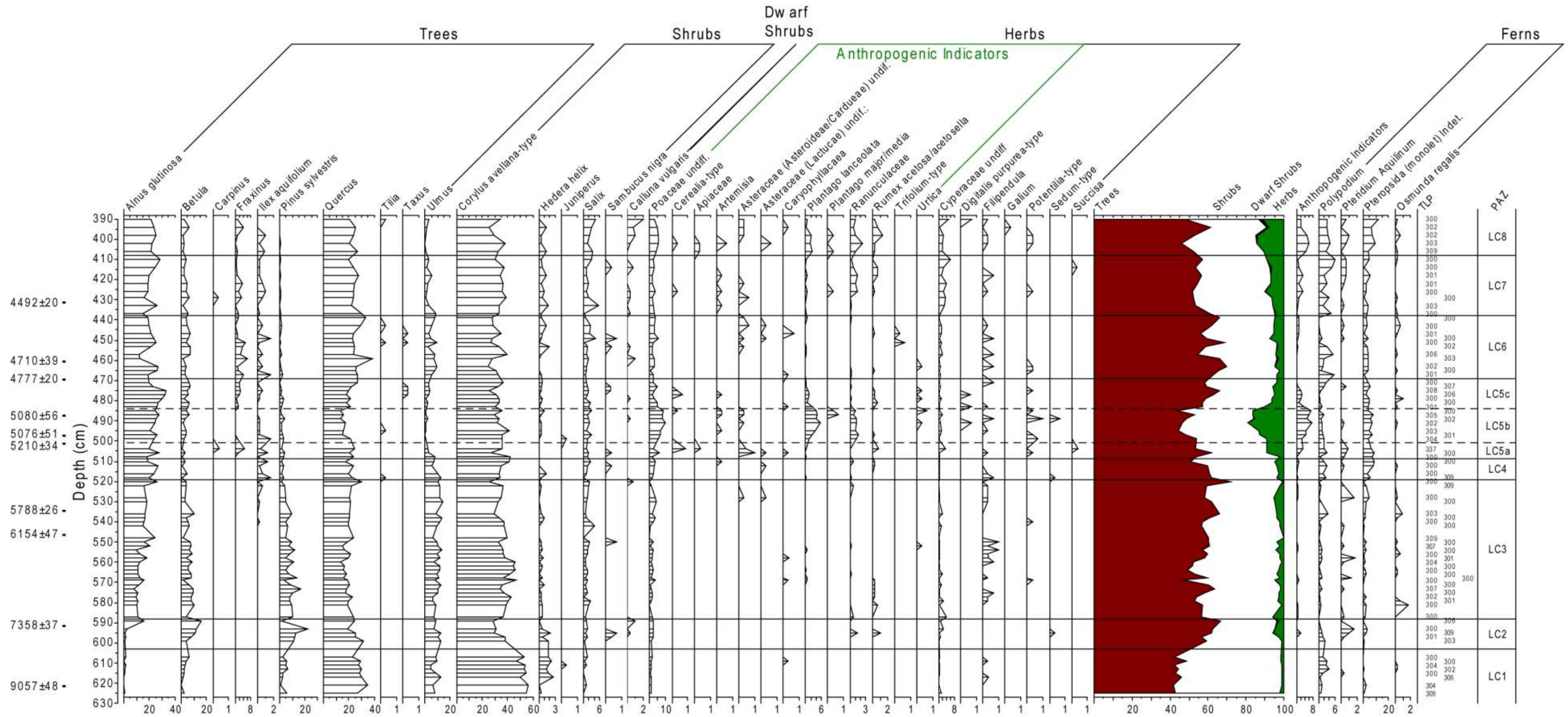

Figure 5.3 Pollen percentage diagram for profile from Lough Cullin (LC).

PAZ/ Depth (cm)	*PDE* PAZ top	Pollen concentration
LC8 (390 – 408)	*2670-2210 cal BC*	This PAZ opens with TLP concentration at 644x10^3 cm^{-3}, which increases to 1259x10^3 cm^{-3} by 398cm. This increase is exhibited across all taxa, with the greatest increase evidence in herb pollen concentration. Total tree and shrub concentration representation doubles, from 337x10^3 cm^{-3} to 662x10^3 cm^{-3} and 237x10^3 cm^{-3} to 408x10^3 cm^{-3} respectively, while there is an almost threefold increase in herb pollen concentration from 68x10^3 cm^{-3} to 175x10^3 cm^{-3}. Thereafter, TLP concentration declines across the PAZ, reaching values of 120x10^3 cm^{-3} by the end of the PAZ, which is again noted across all taxa.
LC7 (408 – 438)	*3010-2490 cal BC*	TLP concentration is 893x10^3 cm^{-3} at the start of the PAZ, declining to 284x10^3 cm^{-3} by 426cm. This reduction is most pronounced in concentration values of trees and shrubs which decrease from 545x10^3 cm^{-3} to 147x10^3 cm^{-3} and 306x10^3 cm^{-3} to 108x10^3 cm^{-3} respectively. The reduction in herbs is less drastic however, as despite the continued decrease in TLP concentration from the start of the PAZ, herb concentration initially increases from 38x10^3 cm^{-3} to 44x10^3 cm^{-3} at 429cm, before declining to 27x10^3 cm^{-3} at 426cm. This is primarily attributable to increased Cyperaceae values between the start of the PAZ and 429cm, from 8x10^3 cm^{-3} to 25x10^3 cm^{-3}, while Poaceae decreases from 26x10^3 cm^{-3} to 11x10^3 cm^{-3} across the same spectra. TLP concentration increases continuously for the remained of the PAZ to values of 893x10^3 cm^{-3} by the 410cm. This is evidenced across all taxa with shrubs and herbs increasing to 300x10^3 cm^{-3} and 83x10^3 cm^{-3} respectively, while the greatest increase is in the concentration of trees to 509x10^3 cm^{-3}.

PAZ/ Depth (cm)	*PDE* PAZ top	Pollen concentration
LC6 (438-469)	*3430-3100 cal BC*	This PAZ opens with TLP concentration at 179x10³ cm⁻³ and remains relatively stable at values of between 250x10³ cm⁻³ and 300x10³ cm⁻³ throughout the PAZ. However, three distinct spikes in concentration values are exhibited in this PAZ, with TLP concentration values increase to 1049x10³ cm⁻³ by 463cm, 1042x10³ cm⁻³ at 451cm and 2084x10³ cm⁻³ at 439cm. This pattern is evidenced across all taxa.
LC5c (469-484)	*3640-3520 cal BC*	TLP concentration remains stable at values of between 200x10³ cm⁻³ and 250x10³ cm⁻³ for much of the PAZ, with an increase to 493x10³ cm⁻³ exhibited at 475cm. This pattern is in general agreement across all taxa.
LC5b (484-501)	*3910-3670 cal BC*	TLP concentration rises to 704x10³ cm⁻³ at the start of this PAZ, with a considerable increase across all taxa except of values of *Ulmus* which increase marginally from 3x10³ cm⁻³ to 4x10³ cm⁻³. Thereafter TLP concentration falls to 489x10³ cm⁻³ by 495cm. This decrease is attributable to a decline in tree concentration from 379x10³ cm⁻³ to 214x10³ cm⁻³, while values of shrubs and herbs remain relatively stable. This reduction relates to decreased *Alnus*, from 166x10³ cm⁻³ to 101x10³ cm⁻³, *Quercus*, from 148x10³ cm⁻³ to 76x10³ cm⁻³, and *Pinus*, from 20x10³ cm⁻³ to 9x10³ cm⁻³. Two separate spikes in TLP concentration are recorded at 491cm and 487cm with TLP concentration rising to over 700x10³ cm⁻³, with a disproportionate increase in both tree and herb concentration exhibited in both instances. At 491cm shrub concentration increase from 206x10³ cm⁻³ to 270x10³ cm⁻³, while herb pollen more than doubles from 64x10³ cm⁻³ to 148x10³ cm⁻³ and trees increase from 214x10³ cm⁻³ to 367x10³ cm⁻³. At 487cm values of shrubs double from 101x10³ cm⁻³ to 217x10³ cm⁻³, while there is an almost threefold increase in trees and herbs from 139x10³ cm⁻³ to 372x10³ cm⁻³ and 44x10³ cm⁻³ to 115x10³ cm⁻³ respectively.

PAZ/ Depth (cm)	*PDE* PAZ top	Pollen concentration
LC5a (501-509)	*4050-3960 cal BC*	This PAZ exhibits increased values of TLP concentration from 521x10^3 cm^{-3} at the top of the previous PAZ to 781x10^3 cm^{-3} by 506cm. This is attributable to increased values of trees and herbs which rise from 264x10^3 cm^{-3} to 482x10^3 cm^{-3} and 26x10^3 cm^{-3} to 70x10^3 cm^{-3} respectively, while shrub concentration declines slightly from 231x10^3 cm^{-3} to 229x10^3 cm^{-3}. The rise in tree concentration primarily relates to increased values of *Alnus*, from 99x10^3 cm^{-3} to 213x10^3 cm^{-3}, *Quercus*, from 90x10^3 cm^{-3} to 161x10^3 cm^{-3}, and *Pinus*, from 10x10^3 cm^{-3} to 31x10^3 cm^{-3}, while *Ulmus* values decline from 45x10^3 cm^{-3} to 26x10^3 cm^{-3}. TLP concentration decreases to 149x10^3 cm^{-3} at the top of the PAZ and this is evidenced across all taxa.
LC4 (509-519)	*4350-4000 cal BC*	This PAZ opens with TLP concentration at 694x10^3 cm^{-3}, increasing to 2084x10^3 cm^{-3} at 516cm before decreasing to 281x10^3 cm^{-3} at the top of the PAZ. This pattern is exhibited across all taxa, although the increase in herb taxa is less pronounced at 516cm. Tree and shrub values treble from 437x10^3 cm^{-3} to 1271x10^3 cm^{-3} and 231x10^3 cm^{-3} to 750x10^3 cm^{-3}, while the increase in herbs is from 25x10^3 cm^{-3} to 62x10^3 cm^{-3} between the start pf the PAZ and 516cm. A similar pattern is recorded in the decrease in TLP concentration between 516cm and the top of the PAZ.
LC3 (519-588)	*4560-4140 cal BC*	TLP concentration remains relatively high for much of the first half of the PAZ, at values of between 500x10^3 cm^{-3} and 750x10^3 cm^{-3}, before decreasing to values of between 250x10^3 cm^{-3} and 350x10^3 cm^{-3} from 542cm. This pattern is exhibited across all taxa, with individual taxa concentration values demonstrating a proportionate response to changing TLP concentration values.

PAZ/ Depth (cm)	*PDE* PAZ top	Pollen concentration
LC2 (588-603)	*6360-5960 cal BC*	TLP concentration continues to fall from the previous PAZ reaching $263x10^3$ cm^{-3} by 599cm, before rising shapely to $896x10^3$ cm^{-3} at 597cm. This increase in TLP concentration is most apparent in values of trees and herbs which increase from $155x10^3$ cm^{-3} to $509x10^3$ cm^{-3} and $2x10^3$ cm^{-3} to $26x10^3$ cm^{-3} between 599cm and 597cm, while shrubs also increase to a lesser degree, from $105x10^3$ cm^{-3} to $360x10^3$ cm^{-3}. The increase in tree concentration is exhibited across all taxa, although the most pronounced increase is in *Betula* which rises from $9x10^3$ cm^{-3} to $74x10^3$ cm^{-3}, while *Pinus, Quercus* and *Ulmus* values increase from $29x10^3$ cm^{-3} to $104x10^3$ cm^{-3}, $82x10^3$ cm^{-3} to $223x10^3$ cm^{-3} and $33x10^3$ cm^{-3} to $92x10^3$ cm^{-3} respectively. TLP concentration decreases to $416x10^3$ cm^{-3} by the next spectrum and continues to decline across all taxa to $255x10^3$ cm^{-3} by the end of the PAZ. The initial reduction at 595cm is primarily exhibit in concentration values of trees and shrubs which decrease to $258x10^3$ cm^{-3} and $134x10^3$ cm^{-3} respectively, while herbs decline marginally to $22x10^3$ cm^{-3}.
LC1 (603-625)	*7700-6430 cal BC*	The profile opens with TLP concentration at $120x10^3$ cm^{-3}, increasing to $1267x10^3$ cm^{-3} at 611cm. This is exhibited across all taxa with trees increasing from $51x10^3$ cm^{-3} to $533x10^3$ cm^{-3}, shrubs from $66x10^3$ cm^{-3} to $717x10^3$ cm^{-3} and herbs from $2x10^3$ cm^{-3} to $16x10^3$ cm^{-3}. This is followed by a reduction to $568x10^3$ cm^{-3} by the end of the PAZ, although the greatest reduction is in shrubs which decline to $282x10^3$ cm^{-3}, while trees and herbs decrease to $276x10^3$ cm^{-3} and $9x10^3$ cm^{-3} respectively.

Table 5.5 Pollen concentration data from Lough Cullin (LC)

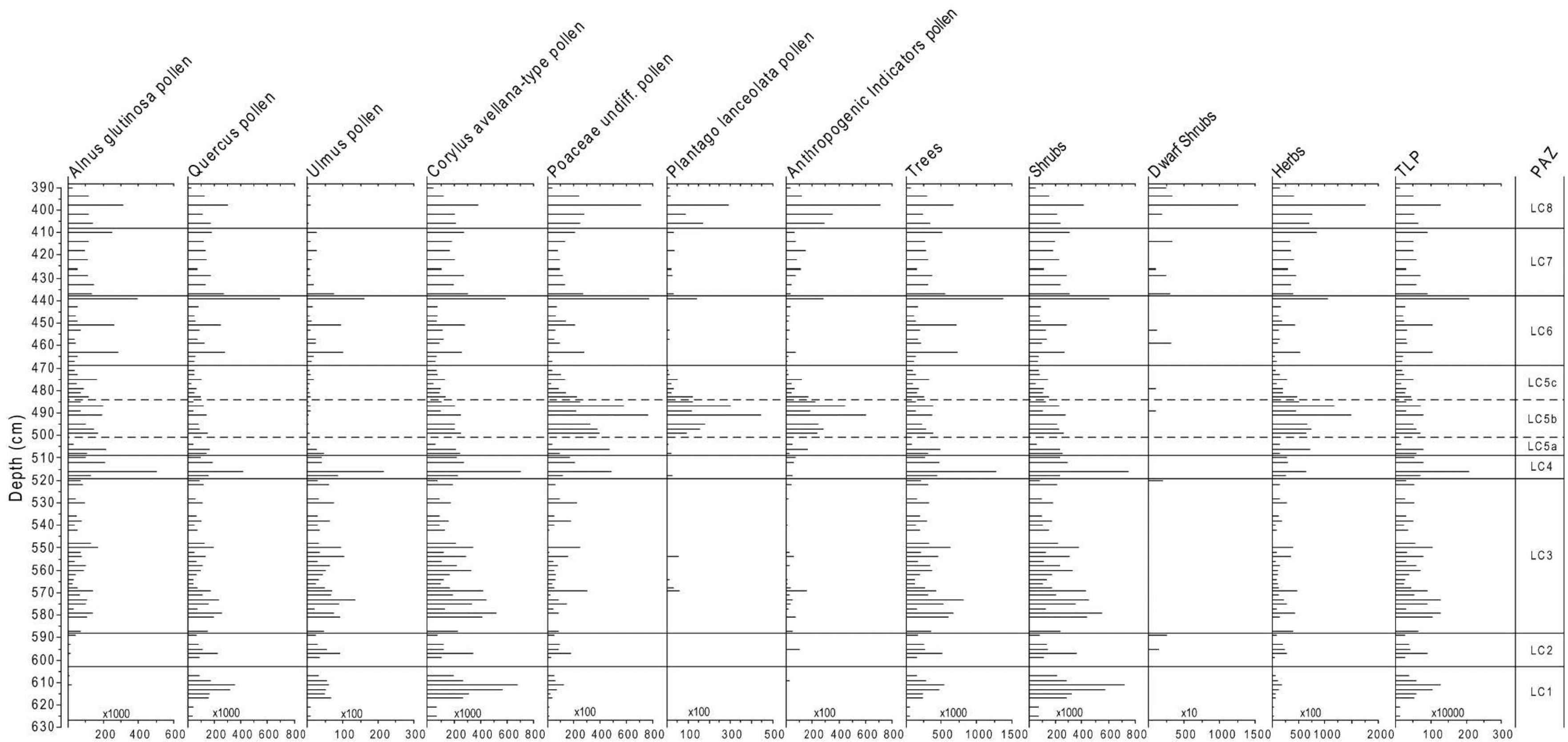

Figure 5.4 Pollen concentration data for selected taxa from Lough Cullin (LC)

5.2.4. Detrended Correspondence Analyses

The results of the DCA (taxa scores only) are presented in Figure 5.5. Axis 1 accounts for 0.10 of the variation and can be recognised a gradient between woodland environments and open habitats. A distinct group of trees and shrubs can be recognised towards the left of the plot, with herbs and associated open ground plants plotting towards the right of Axis 1. Axis 2 accounts for only 0.03 of the variation and it is therefore difficult to establish what this ecological gradient represents.

The broad **Undisturbed Woodland** group can be further separated into two discrete groups, with *Ulmus, Betula* and *Quercus* forming one broadleaf group and *Corylus* and *Sambucus* forming an understorey shrub group. It can also be observed that *Hedera helix* and *Polypodium* plot within this broadleaf group, suggesting these grew as epiphytes, while *Pteridium, Osmunda* and *Filipendula* plot within the latter group which may suggest a degree of openness to this in the understory scrub or these may have grown on the fringes of the broadleaf woodland. *Alnus, Salix* and Cyperaceae plot towards the centre of Axis 1 and may indicate the presence of a **Carr Woodland,** while *Fraxinus* and *Ilex* plot towards the top of Axis 2 and may represent **Post-Disturbance Woodland.**

Herbs typical of **Open Environments** form a distinct group to the right of Axis 1, with a cluster of taxa within this consisting of *Plantago lanceolata, Plantago major/media, Potentilla*, Ranunculaceae and Asteraceae (Lactucae) undif. This group includes predominantly low growing heliophytes commonly found growing together in pastoral/meadow vegetation. Around the edges of this grouping the herbs *Rumex,* Poaceae and Asteraceae (Asteroideae/Cardueae) undif. are located, possibly differentiating taller herb vegetation found on less disturbed soils compared to the previous group.

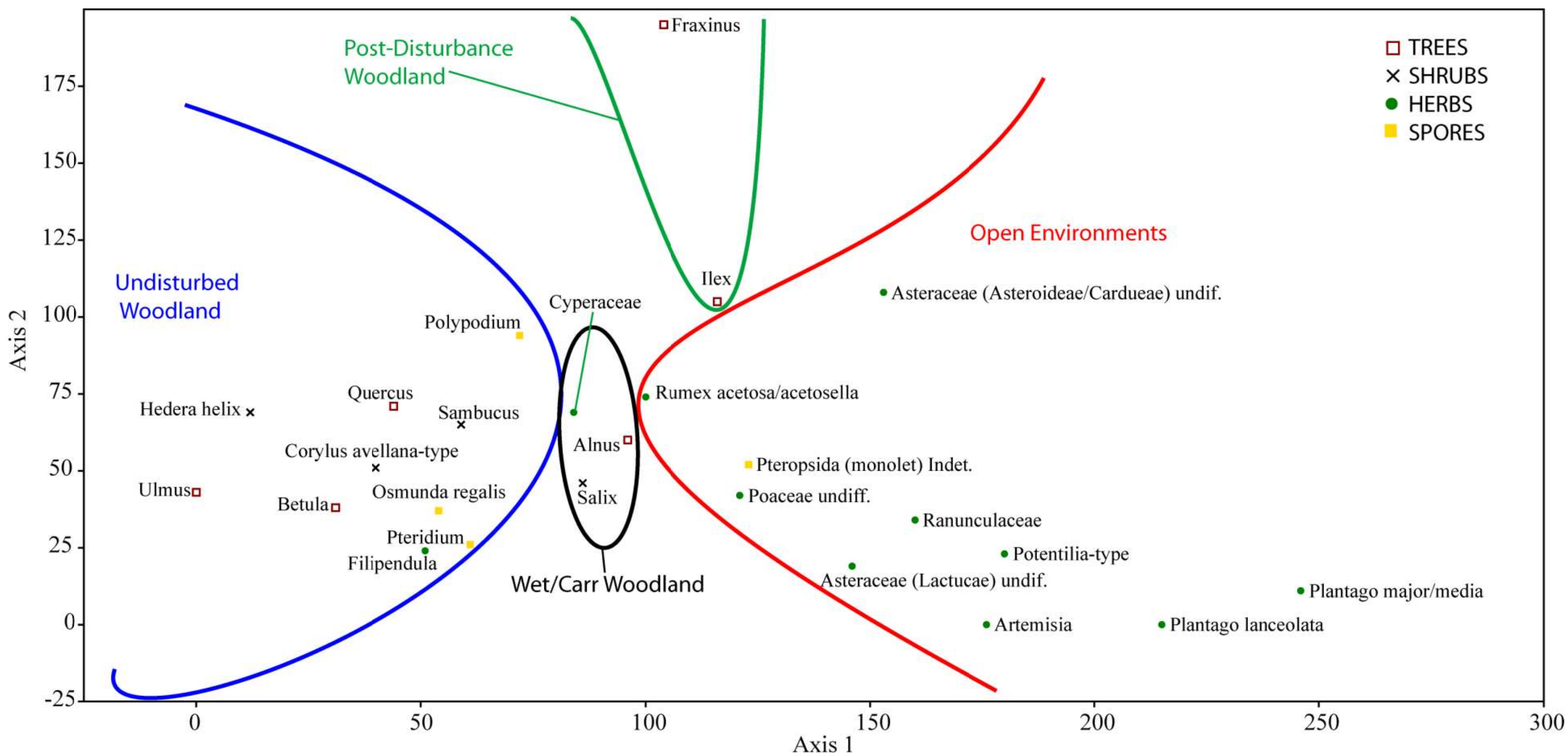

Figure 5.5 Detrended Correspondence Analyses Plot (taxa scores). The lines indicate the recognised groupings (in bold) discussed in the text.

5.2.5. Loss on ignition.

PAZ/ Depth (cm)	PAZ top PDEs	Main features
LC8 (390 – 408)	*2670-2210 cal BC*	OM values at *c*.29% at base of PAZ, increases to *c*.33% at 406cm. Remains stable for rest of the PAZ
LC7 (408 – 438)	*3010-2490 cal BC*	OM values steady at *c*.36% to *c*.37% throughout PAZ, decrease to *c*.29% recorded at 410cm
LC6 (438 – 469)	*3380-3120 cal BC*	OM values steady at *c*.35% to *c*.36% throughout PAZ, marginal decrease to *c*.30% recorded at 463cm
LC5c (469 – 484)	*3640-3520 cal BC*	OM values continue to increase from *c*.30% at beginning of PAZ, to *c*.36% by 469cm
LC5b (484 – 501)	*3910-3670 cal BC*	OM values at *c*.25% at beginning of PAZ, increase to *c*.29% by 489cm. Sharp decrease to *c*.10% at 487cm before recovering to *c*.30% at 485cm
LC5a (501 – 509)	*4050-3960 cal BC*	OM values decrease to *c*.30% at beginning of PAZ, continue to decrease through sub-PAZ. OM values at *c*.24% at top of sub-PAZ
LC4 (509 – 519)	*4350-4000 cal BC*	OM values at *c*.37% at beginning of PAZ, OM values fluctuate between *c*.33% and *c*.35% throughout the PAZ
LC3 (519 – 588)	*4560-4140 cal BC*	OM values at *c*.35% at beginning of PAZ, decrease to *c*.29% by 575cm. OM values fluctuate between *c*.30% and *c*.33% until 525cm where values increase to *c*.36%
LC2 (588 – 603)	*6360-5960 cal BC*	OM values at *c*.40% at beginning of PAZ, decrease to *c*.35% by 597cm and remaining steady for the rest of the PAZ
LC1 (603 – 625)	*7700-6430 cal BC*	OM is *c*.3% at base of profile, increasing to *c*.10% at 621cm and continuing to increase throughout the PAZ. OM reaches *c*.36% at 617cm and fluctuates between *c*.35% and *c*.40% for the remainder of the PAZ

Table 5.6 Summary of Loss on Ignition data from Lough Cullin (LC) provided by Dr. Susan Hegarty, DCU

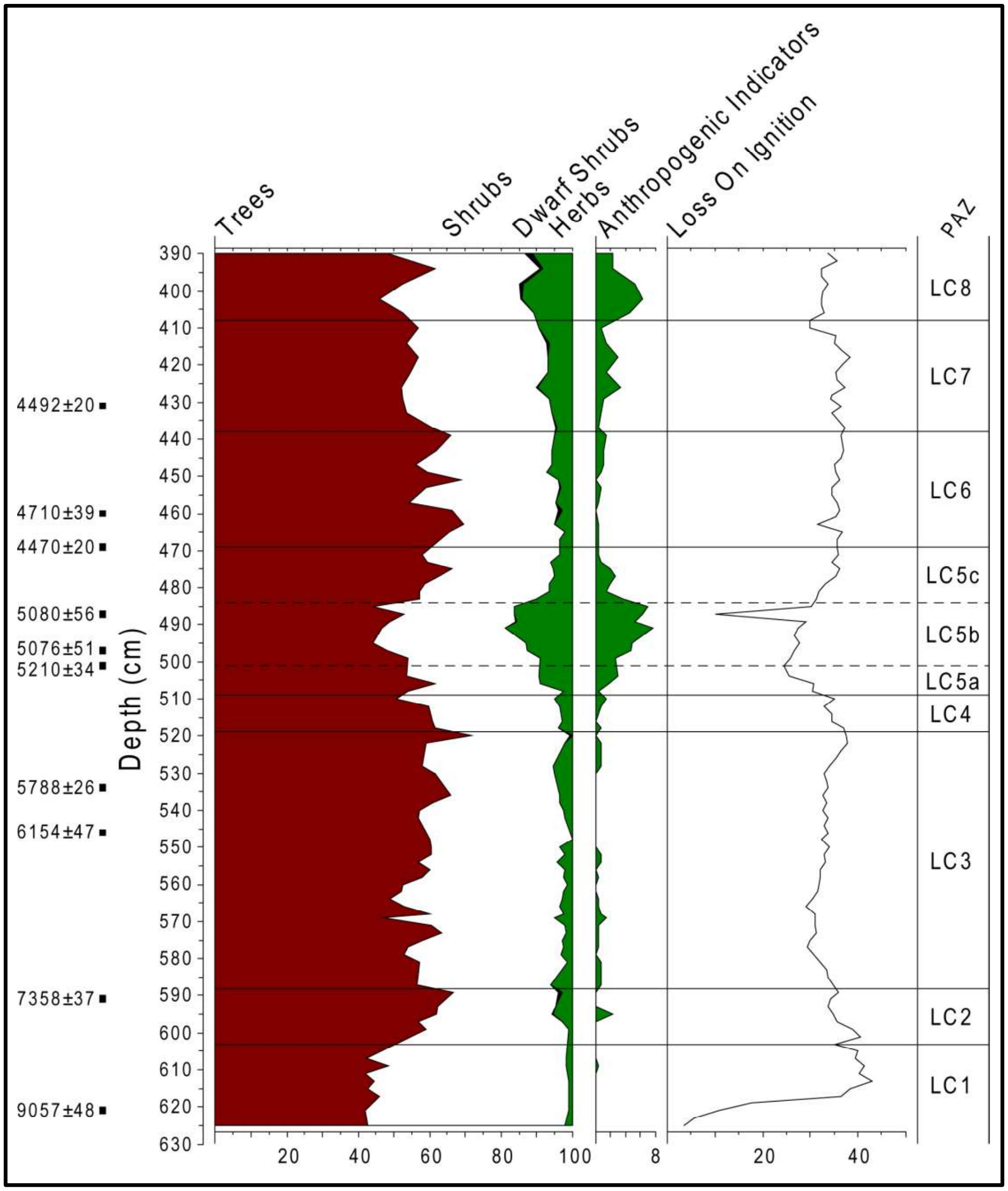

Figure 5.6 Loss on Ignition data from Lough Cullin (LC)

5.3. Interpretation.

5.3.1. PAZ LC1, 625 – 601cm, *8610 – 8000 cal BC* to *7700 – 6430 cal BC.*

The pollen profile from Lough Cullin opens at a date of *8610 – 8000 cal BC* with *Corylus* (hazel) as the dominant taxon with pollen percentage values of over 55% total land pollen (TLP). The arboreal taxa are dominated by *Quercus* (oak), *c.*27%, and *Ulmus* (elm)*, c.*8%, with lesser amounts of *Pinus* (pine)*, c.*5%, and *Betula* (birch), *c.*3%. *Alnus* (alder) is represented but in low values of between *c.*0.5 and *c.*2.5% and may not yet have become a component of the local woodland (cf. Lisitsyna *et al.* 2011; Douda *et al.* 2014). The early Holocene landscape at Lough Cullin would therefore appear to have been dominated by mixed *Quercus-Ulmus*broadleaf woodland (WN2, Fossitt 2000, 50-51), with *Corylus* comprising a major component of the vegetation, probably as an understorey shrub. *Pinus* may have been present, although it is possible that low values reflect long-distance transport from *Pinus* populations growing on poorer soils elsewhere in the region (cf. Pilcher *et al.* 1995; Lageard *et al.* 1999; Lisitsyna *et al.* 2011). *Hedera helix* (ivy) is continuously present throughout PAZ LC1 and the DCA suggest could possibly have been growing as an epiphyte within the deciduous woodland. Values for non-arboreal taxa remain low through PAZ LC1 suggesting open environments were limited within the vicinity of the sampling site. Poaceae (grass), Cyperaceae (sedges) and *Filipendula* (meadowsweet) comprise the main NAP taxa and probably indicate the presence of wet grassland habitats (GS4, Fossitt 2000, 31-32) near the lake margin.

The loss on ignition data opens with low organic content in the basal spectrum of the profile, with values of *c.*4% at 625cm (*8610 – 8000 cal BC*), possibly resulting for low accumulation rates or a large degree of minerogenic in-wash into the lake due to soil instability. The organic context continues to increase to *c.*35% between 625cm and 617cm (*8300 – 7460 cal BC*) and would suggest increased accumulation rates or decreased minerogenic in-wash into Lough Cullin which could possibly signify increased soil stability in the vicinity of the lake. The organic content remains rather stable at values of between 30% and 35% for the remainder of the PAZ.

5.3.2. PAZ LC2, 601 – 588cm, *7700 – 6430 cal BC* to *6360 – 5960 cal BC*.

Corylus, and to a lesser extent *Quercus* and *Ulmus,* temporarily decline through PAZ LC2, while *Pinus, Alnus* and *Betula* increase. *Corylus* declines from 38% at 597cm (*7230 – 6200 cal BC*) to 29% at 595cm (*7030 – 6130 cal BC*) while values for *Betula* increase from *c.*8% to *c.*12% over the same depths. This pattern continues for the remainder of the PAZ, with *Corylus* values continuing to fall to 28% by 589cm, (*6370 – 6010 cal BC*) while *Betula* increases to *c.*16%. The fluctuation in the pollen percentage ratio of *Corylus* to *Betula* appears to be concomitant with an overall reduction in total land pollen concentration, where values decline from 896x10^3 cm^{-3} at 597cm to 416x10^3 at 595cm and continues to decline to 255x10^3 cm^{-3} by 589cm. This reduction in TLP concentration may relate to increased accumulation rates or be suggestive of reduced pollen production.

The fluctuations in values for *Quercus* and *Pinus* do not however, entirely correlate with those of *Corylus* and *Betula.* The reduction in *Quercus* and rise in *Pinus* appear to have occurred later than the fall and increase in *Corylus* and *Betula.* Indeed, *Quercus* values remain relatively constant at *c.*25% before decreasing to *c.*18% at 593cm (*6770 – 6100 cal BC*) and returning to *c.*24% at 589cm, this corresponds with an increase in *Pinus* values from *c.*12% at 595cm to *c.*22% at 593cm before a sharp decline to 2% again at 589cm. *Ulmus* continues to be represented in the profile, although a reduction from *c.*13% to 7% is exhibited between 595cm and 593cm. This could possibly suggest that *Ulmus* populations were also affected by the same conditions which resulted in fluctuation in levels of *Quercus* as both would probably have being on the same drier mineral soils away from the lake edge. Reductions in the deciduous canopy, as evidenced by lower values for *Quercus* and *Ulmus* possibly reflects that these trees were temporarily outcompeted by *Pinus.* This could indicate a shift from a broadleaf woodland (WN2, Fossitt 2000, 50-51) to a mixed broadleaf-conifer woodland (WD2, Fossitt 2000, 54). The lower values of *Hedera helix*, which may have grown as an epiphyte on these broadleaf trees, from 595cm possibly supports the reduction in the deciduous woodland.

Alnus values also demonstrate a marked increase at 589cm, with percentage values climbing from *c.*3% to *c.*16% between 593cm and 589cm, while despite an overall reduction in total land pollen concentration, *Alnus* pollen concentration rises from 10x10^3 cm^{-3} to 40x10^3 cm^{-3} over the same spectra. The values of *Alnus* would strongly infer that the tree had become a component of the local woodland (cf. Lisitsyna *et al.* 2011) and the DCA suggests that the continued, but low presence of *Salix* (willow)*,* probably indicates the establishment of an *Alnus-Salix* woodland carr (WN6, Fossitt 2000, 52) on the wetter soils near the lake.

Little clear evidence that the fluctuations in the principal arboreal taxa could be ascribed to anthropogenic activity or considerably increased levels of vegetation openness is provided in this PAZ. NAP values remain relatively low throughout and ruderal taxa indicative of anthropogenic activity are generally absent. Although, the marginal rise in NAP values, the increased *Pteridium aquilinum* (bracken) representation and decreased organic content exhibited in the loss on ignition data could indicate a degree of increased openness had occurred. The marginal increase in NAP values from 3 to *c.*6%, exhibited at 595cm is however, attributable to increased values of Cyperaceae which the DCA suggests was probably growing within the developing *Alnus-Salix* carr at the lake margin.

5.3.3. PAZ LC3, 588 – 519cm, *6360 – 5960 cal BC* to *4560 – 4140 cal BC.*

In the lower spectra of PAZ LC3 there is a recovery of *Corylus* values to *c.*37% at the expense of *Betula*, which falls to 4%. The earlier trend of low pollen concentration is also reversed, with TLP concentration rising from 255x10³ cm⁻³ at 589cm (*6370 – 6010 cal BC*) to 625x10³ cm⁻³ by 587cm (*6350 – 5920 cal BC*). Thereafter, *Corylus* and *Betula* values remain relatively stable at between 35% and 40%, and 7% and 10%, respectively. The principal arboreal taxa follow a similar pattern for the majority of the PAZ, *Quercus* values range between c15% and *c.*20% while values of *Ulmus* remain relatively stable at between *c.*9 and *c.*13%. This would suggest that a *Quercus-Ulmus-Betula* broadleaf woodland (WN2, Fossitt 2000, 50-51) once again dominated the vegetation on the drier mineral soils around Lough Cullin, with *Corylus* as an understory shrub.

The first appearance of *Ilex aquifolium* (holly) in the pollen record from Lough Cullin occurs in the upper spectrum of PAZ LC3. Aerial dispersal of *Ilex* pollen is particularly poor (Moore *et al.* 1986) so the appearance of *Ilex* would signify the establishment of a substantial population of the taxon, which could flower freely within the *Quercus-Ulmus* dominated broadleaf woodland. Thereafter *Ilex* continues to be recorded continuously, suggesting limited opening in the deciduous woodland canopy (Godwin 1975; Hirons and Edwards 1986; Molloy and O'Connell 1991).

Pinus values fluctuate between 7% to 15% until 548cm (*5330 – 4960 cal BC*), after which it begins to steadily decline to 2% at the top of the PAZ. The values of *Pinus* indicate that if the tree had assumed some importance as a component of the woodland canopy in the previous PAZ, this had ceased to be the case by middle of PAZ LC3 (cf. Pilcher *et al.* 1995; Lageard *et al.* 1999; Lisitsyna *et al.* 2011). *Alnus* continues to increase slowly across the PAZ, reaching values of between 20% and 25% by the top of PAZ LC3, while *Salix* is again present throughout. The expansion of *Alnus* across the PAZ may indicate its replacement of *Pinus* populations (cf. Bradshaw and Browne 1987) which may have developed around Lough Cullin in the previous PAZ. The increased representation of *Alnus*, in addition to the minor increase in Cyperaceae and the more regular occurrence of *Filipendula* may indicate an expansion of the *Alnus-Salix* woodland carr (WN6, Fossitt 2000, 52) at the expense of *Pinus* on the soils near the lake.

Non-arboreal pollen percentages increase marginally at the base and again at top of the PAZ. The sporadic occurrence of light demanding ruderal taxa such as *Plantago lanceolata* (ribwort plantain)*, Rumex acetosa/acetosella* (sheep's sorrels)*,* Asteraceae (Asteroideae/Cardueae) undif. (daisy/thistle), and Asteraceae (Lactuceae) undif. (dandelion) which would further support the presence of small open habitats in the wider landscape. The loss on ignition data exhibits a marginal decrease in organic content at the start of the PAZ, which could possibly indicate increased soil instability and mineral in-wash into the lake. This may be suggestive of marginal woodland reduction at this time. However, form 575cm (*6160 – 5510 cal BC*) to through to the end of the PAZ, the loss on ignition data demonstrates steadily increasing organic content, which would indicate a relatively stable woodland environment.

5.3.4. PAZ LC4, 519 – 509cm, *4560 – 4140 cal BC* to *4350 – 4000 cal BC*.

PAZ LC4 is characterised by a temporary reduction in *Ulmus* values between 518cm (*4550 – 4130 cal BC*) and 512cm (*4420 – 4030 cal BC*) where percentage values decline from *c.*13% to 5% before recovering to *c.*8% by 510cm (*4380 – 4010 cal BC*). This reduction in *Ulmus* corresponds with increased values for *Alnus* from *c.*20% to 27% between 518cm and 512cm, before declining to 19% at 510cm, while *Corylus* values remain stable until 510cm where they increase from 35% to *c.*42%. *Quercus* values fluctuate throughout the PAZ, from *c.*24% at 518cm to *c.*20% at 516cm (*4510 – 4090 cal BC*), before recovering to *c.*25% at 512cm and decreasing again to *c.*18% by the top of the PAZ. *Pinus* and *Betula* are present, but values remain low and *Tilia* (lime) is present for the first time. The further decreased values of *Pinus* during this PAZ would strongly suggest that it had ceased to be a component of the local woodland (cf. Lisitsyna *et al.* 2011).

Ilex representation increases from the previous PAZ and with the occasional record of *Plantago lanceolata*, Asteraceae (Asteroideae/Cardueae) undif., Asteraceae (Lactuceae) undif., *Rumex acetosa/acetosella,* Ranunculaceae (buttercups) and *Artemisia* (mugwort) indicates the presence of open meadow-like environments throughout this PAZ. The marginal reduction in the organic content of the sediment at the start of the

PAZ could be suggestive of further increased soil instability and may reflect increased in-wash into the lake as a result of the reduction in *Ulmus* exhibited at this time. However, despite the alterations in composition of the principal arboreal taxa, overall vegetation is relatively stable as reflected in the minimal rates of change in the percentage ratio of arboreal to herbaceous taxa between 518cm and 512cm.

The reduction in *Ulmus* and fluctuations in the values of *Quercus* do not correspond with an increase in non-arboreal pollen values, which remain stable at *c.*4%. It would therefore appear that the decreased levels of *Ulmus* did not alter the overall composition of the local vegetation, as percentage values of arboreal pollen remain stable with *Alnus* increasing in correlation with this reduction. The increase in *Alnus*, in addition to the increased representation of *Filipendula* may indicate the expansion of the *Alnus* carr on to the previously drier mineral soils close to the lake margin. Alternatively, the increase in *Alnus* representation may result from the reduction in *Ulmus* in the pollen record.

5.3.5. PAZ LC5, 509 – 469cm, *4350 – 4000 cal BC* to *3640 – 3520 cal BC.*

PAZ LC5a, 509 – 501cm*, 4350 – 4000 cal BC* to *4050 – 3960 cal BC.*

This sub-zone sees an additional and more striking reduction in *Ulmus* values than in the previous PAZ. *Ulmus* decreases from 8% at 508cm (*4330 – 3990 cal BC*) to *c.*3% by 506cm (*4270 – 3970 cal BC*) and this is also reflected in the pollen concentration data, where despite an increase in TLP concentration, *Ulmus* concentration values decrease from 45x10^3 cm^{-3} to 26x10^3 cm^{-3} across the same spectra. This reduction is concomitant with a reduction in *Corylus* from *c.*43% to *c.*27% and *Quercus* from 24% to *c.*21%. *Pinus* values remain low, while both *Fraxinus* (ash) and *Carpinus* (hornbeam) appear are recorded for the first time. This reduction in *Ulmus, Quercus* and *Corylus* would intimate increased openings within the deciduous woodland canopy, while the continued presence of *Ilex* across PAZ LC5a would further support this suggestion. However, despite this reduction in *Ulmus* and *Quercus,* overall tree pollen actually increases from 54% to 62%, while shrubs decrease from *c.*44% to *c.*30%. The rise in arboreal pollen is primarily exhibited in increased values of *Alnus* from 18% to *c.*28%. This may suggest that the reduction of *Corylus, Ulmus* and *Quercus* was due to the further expansion of *Alnus* woodland carr. Alternatively, the increased representation of *Alnus* may result from the filtering effect that the woodland carr, fringing the lake, would have had on the herbaceous taxa now growing within the previously closed deciduous woodland canopy.

However, it must be noted that a rise in non-arboreal pollen is also exhibited through PAZ LC5a, where Poaceae values begin to increase from *c.*3 to *c.*6% and ruderal taxa such as Apiaceae (carrot family), Asteraceae (Asteroideae/Cardueae) undif., Asteraceae (Lactuceae) undif., Caryophyllaceae (pinks) and *Rumex acetosa/acetosella* are recorded more frequently across the subzone. *Plantago lanceolata*, though occurring sporadically in PAZ LC3, begins to appear continuously from 504cm (*4210 – 3960 cal BC*), in conjunction with increased values of Poaceae. The overall arboreal to non-arboreal pollen percentage ratio also decreases from 97:3% to 91:9% between 508cm and 506cm inferring the creation of a more open meadow-like environments in the vicinity of the sampling site. *Cerealia*-type (cereals) pollen is recorded in PAZ LC5a at 504cm (*4210 – 3960 cal BC*) and could possibly reflect the start of arable activity locally.

The loss on ignition data indicates increased minerogenic in-wash into Lough Cullin across PAZ LC5a, the percentage of organic content decreases from *c.*35% to *c.*25% between 508cm and 504cm, suggesting increased soil instability locally. This increased soil erosion may relate to the reduction in *Ulmus* and increase in non-arboreal pollen exhibited across this zone. However, while the decline in *Ulmus* continues across the PAZ, values of *Corylus* and *Quercus* recover from 504cm. This appears to be at the expense of *Alnus,* which declines to *c.*19%, and does not signify the reduction in indicators of open environments which remain stable at *c.*9%.

PAZ LC5b, 501 – 484cm, *4050 – 3960 cal BC* to *3910 – 3670 cal BC.*

PAZ LC5b sees a shift in the overall arboreal to non-arboreal pollen percentage ratio from 91:9% to 87:13% between 499cm (*4050 – 3890 cal BC*) and 497cm (*3990 – 3850 cal BC*), peaking at a ratio of 81:19% by 491cm (*3960 – 3780 cal BC*), suggesting the creation of sizable openings within the woodland canopy. This reduction in most pronounced in values of *Quercus* from 22% to *c.*15% between 499cm and 497cm, and *Ulmus* which fall below 1%. Percentage values for other arboreal taxa remain stable between 499cm and 497cm, although there is an increase in *Corylus* at 495cm (*3980 – 3820 cal BC*) from *c.*35% to 41% before declining again to *c.*31% at 491cm. This initial increase in *Corylus* probably relates to increase pollen representation due to the reduction in tall canopy trees (cf. Aaby 1986) rather than an increased levels of *Corylus* growth in the sampling basin. *Alnus* and *Salix* values remain stable, which would suggest that woodland reduction was occurring on the drier mineral soils, while the *Alnus*-*Salix* carr growing at the lake margin was largely unaffected.

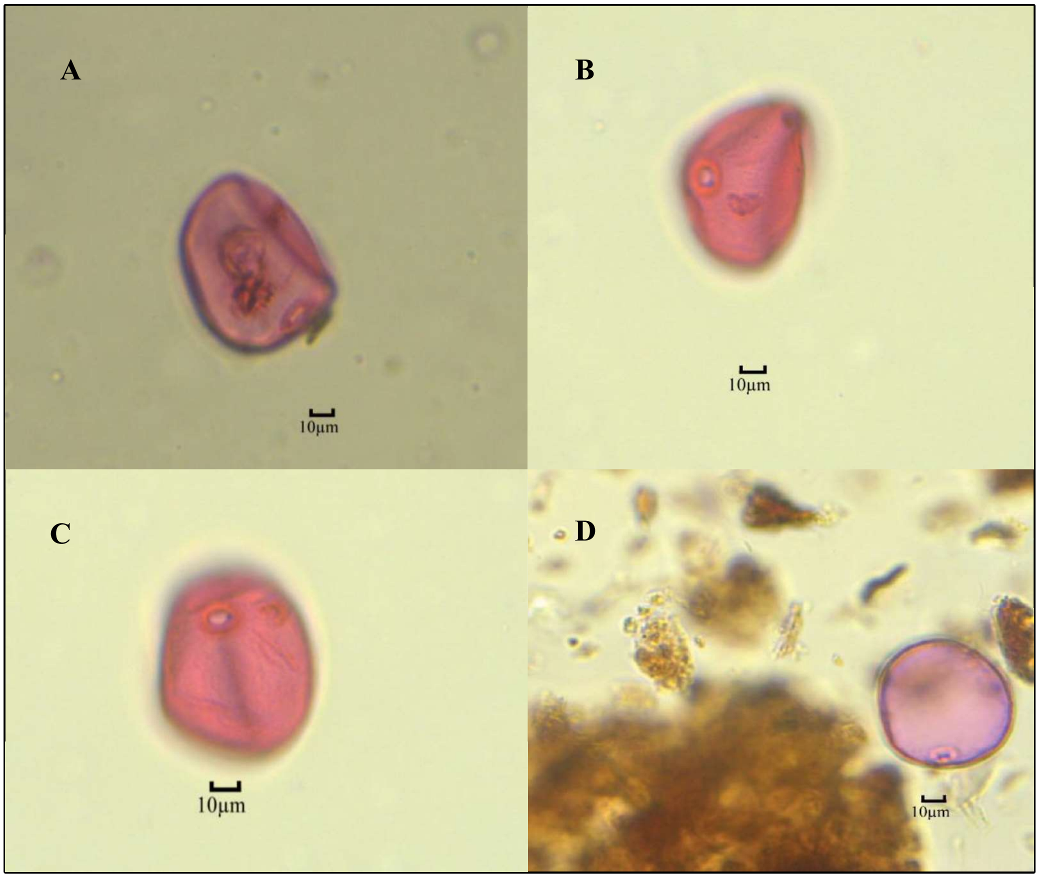

Figure 5.7 Cerealia-type pollen identified at (A) 485cm (48µm), (B) 477cm (47µm), (C) 475cm (46µm) and (D) 426cm (41µm) from Lough Cullin

Concomitant with this reduction in the deciduous woodland is an increase in percentage values for Poaceae from *c.*6% to *c.*7% between 499cm and 497cm, peaking at *c.*10% at 491cm. Additionally, values for *Plantago lanceolata* increase from *c.*1% to *c.*4%, peaking at *c.*6% across the same spectra, while a continuous presence of Ranunculaceae is exhibited across the PAZ. *Urtica* (nettle), *Filipendula, Potentilla*-type (cinquefoil) and Asteraceae (Asteroideae/Cardueae) undif. are present throughout and overall values for anthropogenic indicator taxa (including *Plantago lanceolata*) increase from *c.*2% to 5% and peak at *c.*8% across the same depth range. This would strongly support the interpretation of increased open habitat locally.

These open environments probably consisted of areas of wet grassland (GS4, Fossitt 2000, 31-32), indicated by the presence of Ranunculaceae, Asteraceae (Asteroideae/Cardueae) undif. and *Filipendula*, at the edge of the sampling site, while the presence of *Plantago lanceolata, Urtica,* Asteraceae (Asteroideae/Cardueae) undif. and Asteraceae (Lactucae) undif. would suggest the presence of grassland habitats comparable with dry meadow-like environments (GS2, Fossitt 2000, 30) existed on the drier mineral soils. Herbaceous taxa more indicative of swards such as *Trifolium* (clover) are also recorded at the top of the PAZ which could possibly indicate the presence of grazing animals in the sampling basin

Cerealia-type pollen, in addition to ruderal taxa, *Artemisia* and *Plantago major/media*, which are possibly indicative of cereal cultivation are recorded at 485cm (*3920 – 3690 cal BC*). These ruderal taxa are also identified a slightly earlier at 487cm (*3930 – 3730 cal BC*), which would strongly suggest arable activity in the vicinity of Lough Cullin at this time. The loss on ignition data demonstrates continued reduced percentage values (*c.*26%) of the organic content exhibited across PAZ LC5a, before a marked decline to *c.*10% at 487cm. This would indicate a sharp increase in minerogenic in-wash into Lough Cullin, possibly resulting from increased soil erosion caused by a period of woodland reduction and arable farming.

PAZ LC5c, 484 – 469cm, *3910 – 3670 cal BC* to *3640 – 3520 cal BC.*

PAZ LC5c exhibits a reverse in the arboreal to non-arboreal pollen percentage ratio demonstrated in PAZ LC5b, with non-arboreal pollen percentage decreases from 11% at 483cm (*3900 – 3650 cal BC*) to *c.*7% at 479cm (*3850 – 3600 cal BC*) before declining further to *c.*4% by 471cm (*3700 – 3520 cal BC*). This recovery in arboreal values is initially attributable to an expansion of *Alnus*, rising from *c.*26% at 483cm to *c.*30% by 479cm, while *Corylus* increases from *c.*30% to *c.*34% over the same spectra. *Alnus* continues to increase to *c.*34% at by 475cm (*3780 – 3550 cal BC*), before declining to *c.*20% by the end of the PAZ. *Corylus* and *Quercus* increase from *c.*26% to *c.*37% and from *c.*19% to 27% respectively between 475cm and 471cm. *Ulmus* values also begin to recover during PAZ LC5c, increasing from <1% to *c.*4% by the top of the zone. *Fraxinus* is again present throughout, though at reduced values than the previous two sub-zones while *Taxus* (yew) appears in the profile for the first time.

Despite the increased arboreal values, evidence for open habitats is again exhibited throughout. A continuous curve for *Plantago lanceolata* and *Rumex acetosa/acetosella* is still exhibited, as is the occasional occurrence of *Urtica, Artemisia* and Ranunculaceae, which would indicate the continued existence of meadow-like clearings near the sampling basin. Poaceae values remain stable at 5%, before declining to *c.*2% between 473cm (*3750 – 3530 cal BC*) and 471cm, while *Plantago lanceolata* decreases from *c.*3% to *c.*1% at the start of the PAZ, before declining to less than 1% at the top of the PAZ. This is concomitant with an overall reduction of anthropogenic indicators (including *Plantago lanceolata*) from *c.*4% at the start of the PAZ to *c.*3% by 477cm (*3820 – 3570 cal BC*) and to less than 1% by the end of PAZ LC5*c.* This would indicate decreasing levels of open environments across the PAZ with the probable return to a largely closed deciduous woodland on the drier mineral soils around the lake by *3640 – 3520 cal BC*.

The loss on ignition data exhibited increased percentage values of organic content from the start of PAZ LC5c, with values returning to *c.*35% and remaining steady for the remainder of PAZs LC5c – 6. This would indicate decreased soil erosion around Lough Cullin, inferring increased soil stability due to woodland recovery. However, potential evidence of arable activity is again exhibited in two spectra, *Cerealia*-type pollen is recorded at 477cm (*3820 – 3570 cal BC*) and 475cm (*3780 – 3550 cal BC*), with the ruderal cultivation taxa *Artemisia* also present at 477cm. This would suggest that despite a reduction in vegetation openness and the regeneration of the broadleaf woodland (WN2, Fossitt 2000, 50-51), arable activity was still being undertaken locally.

5.3.6. PAZ LC6, 469 – 438cm, *3640 – 3520 cal BC* to *3380 – 3120 cal BC.*

A period of relative woodland stability is exhibited through PAZ LC6, with increased arboreal values, especially *Ulmus*, which continues to recover. *Ulmus* increases from *c.*3% to *c.*6% at the start of the zone and continue to increase throughout, peaking at *c.*10% at 463cm (*3620 – 3410 cal BC*). *Alnus, Quercus* and *Corylus* values remain relatively stable, although a reduction in *Alnus* from *c.*28% to *c.*13% is exhibited between 463cm and 457cm (*3580 – 3320 cal BC*), where first *Quercus*, from *c.*27% to *c.*39%, and then *Corylus,* from *c.*28% to *c.*40%, increase. A slightly increased representation of *Betula,* from *c.*3% to 7%, and *Fraxinus*, from 2% to *c.*6% is also exhibited over the same spectra, while *Pinus* has reduced to minimal levels. *Salix* increases at the top of the PAZ, *Ilex* is present throughout, while *Tilia* and *Taxus* are again recorded. *Hedera helix* begins to appear continuously from 457cm, which would strongly support reduced human impact and woodland recovery around the lake, as this taxon is sensitive to cutting and grazing (Metcalfe 2005, 635).

The local vegetation record during this PAZ could be characterised as a relatively closed *Quercus-Ulmus-Fraxinus* broadleaf woodland (WN2, Fossitt 2000, 50-51) on the drier mineral soils with *Alnus-Salix* woodland carr (WN6, Fossitt 2000, 52) on the wetter soils near the lake, while *Corylus, Ilex* and *Taxus* were presumably growing in the understory of the deciduous woodland. However, the sporadic occurrence of light-demanding herbaceous taxa would suggest that limited openings did exist in the woodland canopy. These open environments probably consisted of areas of wet grassland (GS4, Fossitt 2000, 31-32), indicated by the presence of Ranunculaceae, Asteraceae (Asteroideae/Cardueae) undif. and *Filipendula*, at the edge of the sampling site, while the occasional presence of *Plantago lanceolata, Urtica,* Asteraceae (Asteroideae/Cardueae) undif. and Asteraceae (Lactucae) undif. would suggest the presence grassland habitats comparable with dry meadow-like environments (GS2, Fossitt 2000, 30) existed on the drier mineral soils. Herbaceous taxa more indicative of swards such as *Trifolium*-type are also recorded at the top of the PAZ which could possibly indicate the presence of grazing animals near the lake.

5.3.7. PAZ LC7, 438 – 408cm, *3380 – 3120 cal BC* to *3010 – 2490 cal BC.*

PAZ LC7 is characterised by a reduction in the deciduous woodland with *Ulmus* values falling from *c.*9% at 437cm (*3370 – 3110*) to 3% at 433cm (*3330 – 3090 cal BC*). This reduction in *Ulmus* corresponds with a decline in *Quercus* from *c.*30% to 23%, while *Alnus* increases from *c.*15% to *c.*26% and *Corylus* values remain stable at *c.*34%. This in addition to increased representation of *Salix,* from less than 1% to *c.*6%, and Cyperaceae, from 1% to 3%, may indicate an expansion of the *Alnus-Salix* carr at the expense of both *Quercus* and *Ulmus.*

Evidence for this expansion of the *Alnus*-*Salix* woodland carr does not continue throughout the PAZ, with values of both *Alnus* and *Salix* declining to *c.*16% and *c.*2% by 429cm (*3300 – 2980 cal BC*) before recovering to 28% and 3% by the end of the PAZ. However, the earlier trend of reduced *Quercus* and *Ulmus* is not immediately reversed, as *Corylus* increases to *c.*39% at 429cm, remaining at similar values until 410cm (*3040 – 2530 cal BC*), where it drops to *c.*30%. *Ulmus* values remain low across the PAZ, while *Quercus* begins a gradual recovery to *c.*28% until 418cm (*3160 – 2690 cal BC*), after which it again decreases to 20%.

Non-arboreal pollen values increase from *c.*5% at 437cm to *c.*10% at 426cm (*3270 – 2890 cal BC*), although this is primarily related to increased Cyperaceae, as Poaceae values remain relatively stable and anthropogenic indicator taxa, including *Plantago lanceolata*, are recorded only sporadically. This would suggest that despite the reduction in broadleaf woodland taxa, little clear evidence for increase openness is provided. However, *Cerealia*-type pollen and the ruderal taxa *Artemisia* and *Plantago major/media* (broadleaf plantain) are again recorded at 426cm and could indicate arable agriculture near the sample basin.

5.3.8. PAZ LC8, 408 – 390cm, *3010 – 2490 cal BC* to *2670 – 2210 cal BC.*

A gradual, yet continuous increase in overall non-arboreal pollen percentage is exhibited across PAZ LC8. The percentage ratio of trees to shrubs to herbs shifts from 57:34:9% at the top of the previous PAZ to 46:39:15% by 402cm (*2910 – 2390 cal BC*). The reduction in trees primarily relates to *Alnus* and *Betula,* which decrease from 28% to *c.*22% and from *c.*5% to *c.*2%, respectively, between 410cm (*3040 – 2530 cal BC*) and 402cm. Values of *Quercus* remain relatively stable, *Ulmus* values are at minimal levels and *Corylus* increases from *c.*31 to 38% over the same spectra, before decreasing to *c.*25% by 394cm (*2750 – 2270 cal BC*). This would suggest that the initial reduction in arboreal pollen was primarily at the expense of *Alnus* and may indicate a reduction in the wet woodland carr close to the lake margin.

The increase in herbaceous taxa exhibited across the PAZ is, however, more representative of increased openness on the drier mineral soils rather than an expansion of wet-loving taxa within the *Alnus*-*Salix* woodland carr. Values of Cyperaceae actually decrease for much of the PAZ, from *c.*7% at the top of the previous PAZ to 2% by 402cm, while *Filipendula, Potentilla*-type and *Digitalis purpurea*-type (foxglove) occur in low values. The increase in non-arboreal taxa is therefore, primarily related to the expansion of open environments away from the immediate lake edge. The increased values of Poaceae, from *c.*2% to *c.*6%, continuous presence of *Plantago lanceolata* from the top of the previous PAZ (*3040 – 2530 cal BC*), in addition to the presence of *Rumex acetosa/acetosella*, Ranunculaceae and Asteraceae (Asteroideae/Cardueae) undif. throughout, would strongly suggest the presence of meadow-like grasslands on the drier mineral soils. *Cerealia*-type pollen, *Artemisia* and *Plantago major/media* are again recorded at 402cm and would possibly suggest that agricultural activity, both pastoral and arable, was once again being practised in the vicinity of the sampling site.

5.4. Discussion

The following section discusses the vegetational history of Lough Cullin as reconstructed through the pollen and loss on ignition analyses. It also focuses on evidence for human agency discovered within these records together with the evidence from regional pollen studies and archaeological sites. The discussion takes place chronologically covering those archaeological periods represented in the pollen profile.

5.4.1. History of woodland development and natural vegetation dynamics

Early Holocene

The pollen record from Lough Cullin, presented here, spans much of the early and middle Holocene from *8610 – 8000 cal BC* to *2670 – 2210 cal BC* and provides insights into vegetational responses to ecological and anthropogenic conditions from the Early Mesolithic to the beginnings of the Late Neolithic/Chalcolithic period. As the profile opens oak and elm are well established and constitute the main tall canopy trees in the landscape around Lough Cullin. Hazel is abundant, comprising a major component of the vegetation, probably as an understorey shrub, while birch and willow had minor roles in the landscape.

Pine may have existed in the landscape, although it is possible that low values of pine reflect long-distance transport from pine growth on poorer soils elsewhere in the region (Pilcher *et al.* 1995, cf. ; Lageard *et al.* 1999). While the low values of pine at

Lough Cullin are comparable with other profiles from the east and midlands (e.g. Caseldine and Hatton 1996; Selby *et al.* 2005), pine had become established at sites such as Kelly's Lough (Leira *et al.* 2007) by 7450 – 7070 cal BC (8220±50, *ß-173463*) which would indicate that while pine did not become a major component of the local woodland at Lough Cullin, it had become established a certain sites within the region.

The early Holocene landscape at Lough Cullin would therefore appear to have been dominated by deciduous woodland. The low levels of non-arboreal taxa would suggest that openenvironments were limited in the vicinity of the sampling site. Ivy appears in the pollen record from Lough Cullin continuously, although holly is absent. The occurrence of ivy and absence of holly is in general accord with evidence from elsewhere in Ireland (Jessen 1949; Singh and Smith 1973; O'Connell 1980). The presence of ivy and true ferns likely represent epiphytes within the deciduous woodland, the presence of both taxa is also evidence within the apparent closed deciduous woodland at Lough Sheeauns (Molloy and O'Connell 1991).

8.2 kyr event

Possible woodland responses to climatic anomalies associated with the 8.2kyr BP event (Ghilardi and O'Connell 2012) is suggested at Lough Cullin from *7030 – 6130 cal BC.* The date range of this climatic anomaly at Lough Cullin could possibly correlate with the anomalies recorded in the Greenland ice-core records (Rasmussen *et al.* 2007; Thomas *et al.* 2007) and evidence at Cooney Lough, County Sligo (Ghilardi and O'Connell 2012) which has been suggested to represent the 8.2kyr BP climate anomaly. This climate anomaly may have resulted from changes in the strength of the Atlantic meridional overturning circulation (AMOC) (cf. Alley *et al.* 1997; Alley and Ágústsdóttir 2005; Ellison *et al.* 2006; Hede *et al.* 2010), which resulted in colder and dry conditions in the North Atlantic region (Alley *et al.* 1997; Barber *et al.* 1999; Alley and Ágústsdóttir 2005; Wiersma and Renssen 2006).

The key features are the decrease in hazel and oak with a corresponding increase in pine and birch in addition to a severe decline in pollen productivity. The abrupt reduction in hazel and oak may have resulted from climatic deterioration as hazel pollen production can be adversely affected by negative climatic shifts such as air frosts, drought or excessive precipitation levels (Tallantire 2002), while oak is also sensitive to early spring and autumn frosts (Giesecke *et al.* 2008). Pine and birch on the other hand is more tolerant to low summer temperatures and can be a rapid coloniser given suitable conditions (Atkinson 1992; Richardson and Rundel 1998; Paus 2010), conditions which possibly arose as a result of lower temperatures and a decrease in precipitation.

As fluctuations occur in values of birch and hazel, both of which respond rapidly to environmental change, it is assumed that these are reflecting climate, especially thermal, anomalies. These and other changes such as the expansion of pine and the marginally increased non-arboreal pollen values, indicate a possible change to a more continental climate between *7030 – 6130 cal BC* and *6370 – 6010 cal BC,* which possibly involved not only colder winters but also lower summer temperatures and a considerably lower annual thermal sum (cf. Huntley 2012).

This reduction in thermophilus taxa and an increase in cool-tolerant trees is also exhibited elsewhere on the island. Cooney Lough, County Sligo (Ghilardi and O'Connell 2012) showed a marked reduction in pollen from cold-intolerant arboreal taxa, hazel and oak, synchronous with an expansion of trees favouring cooler conditions such as pine and birch (Ghilardi and O'Connell 2012). Fluctuations in the frequency of juniper in high-resolution records from An Loch Mór, Inis Oírr (Molloy and O’Connell 2004; O'Connell and Molloy 2005) and increased representations of pine at the expense of hazel recorded at a time of increased erosion from Lough Maumeen, Connemara (Huang 2002), may also represent an expression of the 8.2kyr event.

Pre-’Elm Decline’

Following this potential 8.2kyr BP ‘event’ and hazel recovers at the expense of both birch and pine, possibly indicating improvements in the thermal environment. An increase in alder is also recorded at Lough Cullin at this time and this increase is usually regarded as marking the Boreal/Atlantic transition (Jessen 1949; Mitchell 1951). The pollen percentage values of alder at Lough Cullin would support the suggestion that the tree had become established within the local landscape (Douda *et al.* 2014) and may signify an expansion of damp woodland at the lake edge. Alder was presumably colonising the wetter soils at the edges of the open water, leading to the formation of alder carr-woodland. Whilst a mixed elm-oak-hazel woodland was growing on the drier mineral soils in the wider landscape, a trend which has been suggested from palaeoenvironmental evidence from other sites in the area (e.g. Caseldine and Hatton 1996; Gearey *et al.* 2010; Timpany 2009).

The date for the establishment of alder at Lough Cullin appears to be slightly earlier than the general date proposed its establishment across Ireland, *c.*7000 BP (*c.*7700 cal BP) (Birks 1989; Bennett and Birks 1990; Tallantire 1992), although alder does also appear to have become established at certain sites prior to this (O'Sullivan 1991). This spread and expansion of alder post-7000 BP has been found to be irregular and erratic in space and time (Bennett and Birks 1990) and this temporal diversity is evidenced from previous pollen profile from the south and east of Ireland.

Alder becomes established after 5490 – 5010 cal BC (6315±110, *D-115*) at Belle Lake (Craig 1978), after 5480 – 5070 cal BC (6330±80, *Beta-65095*) at Clara Bog (Connolly 1999; Crushell *et al.* 2008), while at Lough Kinale (Ballywillin Crannog core) (Brown *et al.* 2005; Selby *et al.* 2005) alder expands after 5720 – 5560 cal BC (6720±40, *Beta-173320*). In contrast, alder does not become a major component in the woodland canopy until 4720 – 4400 cal BC (5710±60, *Beta-95517*) at Cornaher Lough (Heery 1997, 35) and not until 4450 – 4330 cal BC (5510±20, *NZA-34453*) at Clowanstown (Gearey *et al.* 2010). A similar situation is evidenced in the west and north and it appears that alder may have migrated to Ireland in the early Holocene but failed to become a major component of the wider woodland canopy until environmental conditions favoured its expansion after 7000 BP (Bennett and Birks 1990).

Low values for non-arboreal pollen and ferns suggest the woodland around Lough Cullin had a rather closed structure, with limited open environments. However, the continuous presence of holly, indicating the local establishment of the taxa, may infer that the deciduous woodland was not as closed as suggested. Open woodland structures are envisaged as being the ideal environment to facilitate the establishment of holly (Molloy and O'Connell 1987, 209), however the profile from Lough Cullin provides no evidence of such changes to the woodland structure occurring. Indeed, non-arboreal indicators of open environments such as ribwort plantain, whilst present only sporadically prior to the establishment of holly, cease during the initial stage of holly expansion.

'Elm Decline'

A temporary reduction in elm was noted between *4540 – 4130 cal BC* and *4420 – 4030 cal BC*, although this reduction is not sustained, and values do recover by *4320 – 3990 cal BC.* This reduction may represent multiple fluctuations in elm populations also exhibited at Lough Gur (Almgren 1989; 2001), Cornaher Lough (Heery 1997), Clara Bog (Connolly 1999; Crushell *et al.* 2008) and possible from the undated profile from Scragh Bog (O'Connell 1980). This reduction in elm may alternatively provide evidence for a more protracted and gradual decline in elm than expected when discussing the 'Elm Decline'. A similar protracted and gradual 'Elm Decline' is evidenced at Lough Mullaghlahan (Fossitt 1994) and Lough Kinale (Ballywillin crannog) (Brown *et al.* 2005; Selby *et al.* 2005), although in the latter this was suggest to have resulted a combination of a hiatus and slow accumulation rates.

A more sustained reduction in elm is exhibited from *4320 – 3990 cal BC*, and likely represents the mid-Holocene 'Elm Decline' in the region. The date for this appears earlier than the chronologically 'fixed' date for the mid-Holocene 'Elm Decline' in Ireland , however, this temporal synchroneity is debatable (See **Chapter 7**, also Parker *et al.* 2002; Whitehouse *et al.* 2014; Griffiths and Gearey 2017). This feature of low elm values is sustained until *3640 – 3480 cal BC*, suggesting a duration of *410 – 790* for this 'event' in the region. (The 'Elm Decline' and its relationship to the Mesolithic/Neolithic transition is explored further in **Chapter 7**)

Following the mid-Holocene 'Elm Decline' pollen diagrams in Ireland frequently demonstrate evidence for woodland instability and/or early agricultural activity (e.g. Mitchell 1942; O'Connell 1980; O'Connell *et al.* 1988; Molloy and O'Connell 1991; Fossitt 1994; Heery 1997; Connolly 1999; Brown *et al.* 2005; Selby *et al.* 2005; Caseldine and Fyfe 2006; Molloy 2008; Ghilardi and O'Connell 2013; Molloy *et al.* 2014). The reduction in elm at Lough Cullin is followed by an increase in indicators of open environments, with increased representation of grasses and ribwort plantain. Greater reductions in the woodland canopy and increased open habitats than exhibited in the arboreal to non-arboreal pollen percentage ratio could be suggested by the increased values for holly following the reduction in elm (Moore *et al.* 1986). Holly will best regenerate and flower when the woodland canopy is disturbed or alternatively during the initial stages in woodland succession (Molloy and O'Connell 1991, 98).

Therefore, some woodland disturbance is likely to have occurred to facilitate the expansion of holly. This increase in holly is also apparent from Kilmaddy Lough (Hirons and Edwards 1986), Lough Catherine (Hirons and Edwards 1986), Lough Sheeauns (Molloy and O'Connell 1987; 1991) and Lough Namackanbeg (O'Connell *et al.* 1988) and has tentatively been suggested as evidence for soil erosion in correlation with suspected woodland disturbance, as representation of holly can be enhanced in lake sediments through the erosion of soil humus layers following deforestation (Pennington 1979). Further possible supporting evidence for woodland reduction can be inferred from the loss on ignition data, which exhibits increased minerogenic in-wash into Lough Cullin, suggesting increased soil erosion locally immediately following the 'Elm Decline'. It is therefore conceivable that the degree of woodland reduction around Lough Cullin was greater than suggested by the pollen percentage values for non-arboreal taxa.

Post-'Elm Decline'

Further reductions of the woodland canopy and a possible *Landnam* phase is exhibited from *4270 – 3970 cal BC*, where the percentage values for non-arboreal taxa continue to increase and greater diversity of ruderal taxa is exhibited. This *Landnam* phase demonstrates its greatest intensity until *3890 – 3650 cal BC*, indicating a potential woodland clearance phase of between *140 – 530* years. Non-arboreal pollen taxa continue to rise and the presence of light demanding non-arboreal taxa such as ribwort plantain, buttercups, docks, daisies, mugwort and nettles would strongly indicate open environments around Lough Cullin. The pollen percentage diagram would indicate the clearances mainly involved oak, with hazel effected to a lesser degree. The identification of cereal pollen at *3950 – 3670 cal BC* and again from *3830 – 3530 cal BC* would indicate arable farming while the expansion of ribwort plantain, daisies, docks and buttercups would also suggest pastoral activity (see below).

It is appropriate here to briefly address the use of the term *Landnam* within both archaeological and palaeoecological research in Ireland. The term *Landnam,* literally meaning the 'taking of land', original coined by Iversen (1941), envisaged a period of rapidly shifting Neolithic agricultural and woodland clearance, facilitated through the adoption of 'slash and burn' woodland management strategies. The Iversen *Landnam* model consists of three phases, which could be recognised in palynological profiles. The first phase represented the actual forest clearance by cutting and burning, where initially elm declined, followed by the decrease in oak. This was followed by the agricultural phase, involving grazing and cereal cultivation. Anthropogenic and grazing indicators increased considerably, in particular ribwort plantain, but also grass, cultigens, and additional anthropogenic indicator taxa. Finally, the third phase represented the abandonment of the pastures and fields, allowing woodland regeneration. This was exhibited through increased representation of hazel, oak and ash, while anthropogenic and grazing indicators decreased and disappeared almost completely from the record.

An additional Neolithic *Landnam* model was later outlined by Troels-Smith (1953), which was envisaged to have occurred prior to the Iversen *Landnam* model. This model suggested that various agricultural indicators, such as cereal-type pollen, occurred contemporaneously with the mid-Holocene 'Elm Decline'. Troels-Smith (1953) suggested that the reduction in elm reflected pollarding of the trees for the purpose of cattle fodder. Together with the absence of pastures, deduced from low initial representation of ribwort plantain, Troels-Smith concluded that a farmer culture existed preceding the Iversen *Landnam*, mainly based on small-scale arable farming with livestock kept within enclosures throughout the year.

However, in the Irish archaeological and palaeoecological literature on the Mesolithic/Neolithic transition, the term *Landnam* has come to define woodland clearance in the context of a prehistoric farming economy (cf. Molloy and O'Connell 1987). Unlike the Iversen (1941) model, however, this does not necessarily envisage a 'slash and burn' woodland management strategy or shifting agricultural regime, but defines phases of Early Neolithic woodland clearance and agricultural activity of up to several centuries (O'Connell and Molloy 2001). Indeed, the palynological and archaeological evidence suggests that Early Neolithic farmers in Ireland did not engage in shifting cultivation *contra* Iversen's (1941) *Landnam* model, but rather practiced longer-term, fixed-plot agriculture (Whitehouse *et al.* 2014, 198). It is therefore essential to be aware that, in the context of the Early Neolithic in Ireland, the term *Landnam* has come to mean woodland clearance to facilitate sedentary agricultural activity and does not encompass the 'slash and burn' woodland clearance and shifting agricultural regime envisaged by Iversen (1941).

Post-Landnam

From *3890 – 3650 cal BC* there is a distinct recovery in oak, ash and elm, although elm does not fully recover until later. While the there is an overall reduction in non-arboreal taxa, the continued presence of light demanding taxa such as ribwort plantain would continue to suggest the presence of open habitat environments around Lough Cullin. It is not until *3640 – 3480 cal BC* that overall arboreal, especially elm, values return to their pre-'Elm Decline' levels and the continued presence of ribwort plantain is interrupted. Elm regenerates strongly, although not to previous levels, while ash continues to play an increased role in the woodland dynamic. The recovery of elm is mirrored in other sites where elm played an important role in pre-'Elm Decline' vegetation such as Scragh Bog (O'Connell 1980), Corlea 9 (Caseldine and Hatton 1996), Sluggan Bog (Smith and Goddard 1991) and An Loch Mór (Molloy and O'Connell 2004). The expansion of yew, noted in numerous sites (Watts 1984a; O'Connell *et al.* 1988; Mitchell 1990a; Molloy 2002), is not evidenced at Lough Cullin. This is in correlation with the findings of O'Connell and Molloy (2001, 102-103), which suggest the expansion of yew was a more westerly/south-westerly phenomenon, although a slender curve for yew is recorded at Clara Bog (Connolly 1999; Crushell *et al.* 2008). Despite this woodland stability a certain degree of openness is signified by the sporadic occurrence of ribwort plantain, daisies, docks and buttercups.

The recovery of elm and the return to a closed woodland canopy appears to be sustained until *3390 – 3110 cal BC*, when a second reduction in elm is apparent. This would appear to mirror examples from elsewhere in the region, at Corlea 9 (Caseldine and Hatton 1996), ash expands at the expense of elm from 3340 – 2890 cal BC (4400±80, *GU-2140*) while a marked reduction in elm is noted from 3030 – 2910 cal BC (4360±20, *NZA-34452*) at Clownstown (Gearey *et al.* 2010). This reduction in elm at Lough Cullin is primarily concomitant with increased representations of alder, a slight increase in ash and marginally increased levels of non-arboreal taxa. However, while there is a marginal increase in non-arboreal pollen percentage following this second reduction in elm it is primarily attributable to increase wet-loving taxa such as sedges and meadowsweet suggesting a possible expansion of open areas adjacent to the lake edge rather than increased open dryland habitats driven by anthropogenic activity.

The re-instatement of a continuous curve for ribwort plantain and other light demanding ruderal taxa from *3040 – 2530 cal BC*, suggests the woodland regeneration phase last between *500 – 1040* years. The renewed presence of cereal-type pollen at *3330 – 2840 cal BC* and *3050 – 2290 cal BC* would also suggest the recommencement of anthropogenic activity around Lough Cullin. Thereafter non-arboreal pollen percentage values continue to increase for the remainer of the profile at the expense of primarily hazel and oak. This would appear to contrast with other pollen diagrams from the region, which do not show much evidence for human activity in the final centuries of the Neolithic (e.g. Heery 1997; Connolly 1999; O'Connell and Molloy 2001; Stefanini 2008).

5.4.2. Human impact and early farming

The Mesolithic period is represented in the Lough Cullin profile by the basal four zones of the pollen profile presented here, which suggest that the local landscape was relatively closed during this period. Openings within this woodland would have existed though allowing periods in which more shade-intolerant taxa could flourish. Despite evidence for sporadic small openings in the woodland during the Mesolithic, it is impossible to state definitively if these were caused by anthropogenic activity or natural mechanisms. While many authors suggest deliberate human causation for similar situations elsewhere (e.g. Smith 1970; Simmons and Innes 1996; Innes *et al.* 2003; Warren *et al.* 2014), an identical signal would likely be identified in the case of a natural cause for such openings (cf. Brown 1997), such as wind throw. The potential role of storms in palaeoenvironmental records is often underplayed, high winds can have a significant impact on woodlands causing the felling of trees (Allen 1996; 1998; Blackburn *et al.* 1988; Denslow *et al.* 1998) and creating environments for light demanding ruderal taxa to become established in an identical manner to anthropogenic woodland disturbance. Despite the obvious presence of Mesolithic hunter-gather populations identified in the archaeological record it difficult to establish what trace these left on the natural landscape around Lough Cullin.

The earliest unequivocal evidence for anthropogenic activity at Lough Cullin is interpreted as occurring after the reduction in elm. As outlined above the 'Elm Decline' is often used in palynological investigations as a chronological proxy for the start of the Neolithic, though these two events may not be a synchronous as previously indicated (cf. Whitehouse *et al.* 2014). At Lough Cullin, Early Neolithic anthropogenic activity, suggested by the initiation of a continuous presence of ribwort plantain and overall increased values for non-arboreal pollen (especially ruderal taxa indicative of agriculture), is recorded from *4210 – 3960 cal BC*, *0 – 220* years after the decline in elm. This would concur with other Irish pollen records (e.g. Molloy and O'Connell 1987; O'Connell and Molloy 2001; Ghilardi and O'Connell 2013; Molloy *et al.* 2014), which have also demonstrated a chronological separation between the 'Elm Decline' and Early Neolithic human disturbance. This may be said to refute suggestions of an anthropogenic cause for the reduction in elm identified at various locations. However, it must be stated that this time lapse may have resulted from increased stimulation of arboreal pollen production resulting from openings in the woodland canopy (cf. Aaby 1986).

The increased representation of anthropogenic indicators, such as ribwort plantain, daisies, dandelions, buttercups, docks and pinks, would strongly suggest an increase in open environments in the vicinity of the lake. This increase is concomitant with an overall reduction of arboreal pollen especially oak and hazel in addition to the previously mentioned decline in elm and would infer a deliberate opening of the woodland canopy on the drier mineral soils for the provision of agricultural land (i.e. a *Landnam* phase). This is further supported by the observed increased minerogenic in-wash into the lake suggesting soil erosion possibly caused by deforestation. The increase in NAP, especially grasses and ribwort plantain, following the reduction in elm is also exhibited at other sites in the region such as Scragh Bog (O'Connell 1980), Corlea 9 (Caseldine and Hatton 1996), the Bog of Cullen (Molloy 2008) and further afield (e.g. Pilcher and Smith 1979; Almgren 1989; Molloy and O'Connell 1991; 1995a; 2004; O'Connell and Molloy 2001; Ahlberg *et al.* 2001).

While Early Neolithic agriculture appears to have had an impact in certain pollen records many sites in the region show little anthropogenic impact such as the pollen profiles from Clara Bog (Connolly 1999; Crushell *et al.* 2008), Cornaher Lough (Heery 1997) or Ballinderry Lough (O'Carroll 2012), while only a marginal increase in grass and the sporadic occurrence of ribwort plantain is noted at Kelly's Lough (Leira *et al.* 2007). This would infer that early agriculture did not always have a substantive role in the wider regional landscape. Early Neolithic agriculture was likely a spatially heterogeneous phenomenon (Whitehouse *et al.* 2014) with varying levels of intensity, if any, across the broader regional landscape.

The Early Neolithic phase of activity at Lough Cullin, defined by the continuous presence of the anthropogenic indicator ribwort plantain, is well defined from *4210 – 3960 cal BC* until *3640 – 3480 cal BC*, a duration of *360 – 670* years based on the OxCal age-model employed here. If the age-model is correct then the opening of the woodland canopy, which can be said to represent Neolithic human impact, commenced at Lough Cullin considerably earlier than the suggested date for the introduction of Neolithic houses and cereal cultivation in Ireland (See **Chapter 7,** also **Chapter 4**; McSparron 2008; Cooney *et al.* 2011; McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). The high values of ribwort plantain and buttercups infer the presence herbaceous grassland with a considerable degree of taxonomic biodiversity indicative of pastoral agriculture. The identification of this intense *Landnam* phase is also apparent in the loss on ignition data which continues to demonstrate evidence for increase soil instability throughout, with a major spike in inorganic in-wash recorded at *3950 – 3670 cal BC.* This would appear to suggest that the peak in woodland reduction and open habitat creation was prior to the introduction of aspects of the Neolithic such as the 'House Horizon' (McSparron 2008; Cooney *et al.* 2011; McLaughlin *et al.* 2016) and cereal cultivation (McClatchie *et al.* 2014; Whitehouse *et al.* 2014).

This initial stage of the *Landnam* phase likely occurred in the context of a pastoral agricultural economy, based on the high representation of pastoral indicators at this stage. Cereal-type pollen is recorded at *3950 – 3670 cal BC*, *120 – 500* years after the start of the *Landnam* and again from *3830 – 3530 cal BC*, with the presence of ruderal taxa indicative of arable agriculture such as mugwort and pinks (Behre 1981) also noted. Cereal-type pollen, notwithstanding the issues relating to identification, is the surest indicator of anthropogenic, especially arable activity in pollen records (cf. Behre 1981) and given the temporal context and the presence of ruderal taxa strongly associated with cereal cultivation at these spectra, it is plausible that arable farming had assumed some importance in the vicinity of Lough Cullin after *3950 – 3670 cal BC.* Evidence from further south at Newrath (site 34) (Timpany 2009) would also strongly suggest that Neolithic arable agriculture had begun to be practiced in the wider region at this time. Perhaps the best and more reliable evidence of Early Neolithic agriculture around Lough Cullin is the presence of charred cereal grain dating to this period found at Granny (Site 27), Earlsrath (site AR035), Kilkeasy, Newrath (Site 35) and Scart. The finding of charred grain from Neolithic sites around Lough Cullin helps to put the cereal pollen grains in context. The charred grain together with the pollen evidence indicates cereal cultivation was undertaken in the Early Neolithic in this area of southeast Ireland.

The Lough Cullin profile provides evidence for the continuity of farming for *360-670* years, after which woodland regeneration occurs and a decline in anthropogenic indicators becomes apparent from *3640 – 3480 cal BC.* The steady increase in arboreal pollen is likely to indicate the regeneration of woodland and abandonment of this part of the Lough Cullin area for agricultural use. Despite the occasional occurrence of ribwort plantain, this marks the beginning of a less intensive use of the landscape around Lough Cullin. A similar pattern of re-afforestation and abandonment is noted during the Middle Neolithic in other parts of Ireland (e.g. Pilcher and Smith; O'Connell 1980; Almgren 1989; Molloy and O'Connell 1991; 1995a; 2004; Caseldine and Hatton 1996; Hirons and Edwards 1986; O'Connell and Molloy 2001; Ahlberg *et al.* 2001; Molloy 2008; Ghilardi and O'Connell 2013; Molloy *et al.* 2014) and draws comparisons with the traditional *Landnam* clearance models.

Sites which demonstrated little, if any anthropogenic activity during the Early Neolithic also fail to do so at this time (e.g. Connolly 1999; Heery 1997; O'Connell *et al.* 1987; 2001; Lamb and Thompson 2005; Leira *et al.* 2007; Gearey *et al.* 2010; O'Carroll 2012; Crushell *et al.* 2008) leading to suggestions of period of declining activity compared to the preceding phase, rather than a shift in activity to sites elsewhere in the region. This reduction in anthropogenic activity around Lough Cullin is also apparent in the archaeological record. The number of confirmed Middle Neolithic archaeological sites in the region is substantially lower than in the preceding Early Neolithic phase which is in keeping with the archaeological picture across the island (Whitehouse *et al.* 2014; McLaughlin *et al.* 2016).

Evidence for sustained human activity is absent until *3040 – 2530 cal BC* when ribwort plantain and other anthropogenic indicators again begin to appear more frequently, while cereal-type pollen with accompanying ruderal taxa mugwort and broadleaf/hoary plantain are again recorded at *3330 – 2840 cal BC* and *3050 – 2290 cal BC.* This would possibly suggest that agricultural activity, both pastoral and arable, was once again being practised in the vicinity of the sampling site after a rather long period of *500 – 1040* years in which woodland regeneration and low human activity were the defining characteristics of the pollen profile form Lough Cullin. The potential reappearance of agricultural activity in the region during the Late Neolithic is also hinted at from Clowanstown (Gearey *et al.* 2010), where values of grass and ribwort plantain increase marginally from 2890 – 2690 cal BC (4200±20, *NZA-34450*), and from other sites across the island (e.g. Pilcher and Smith 1979; Fossitt 1994; Molloy and O'Connell 2004). The archaeological evidence also suggests a limited Late Neolithic presence recorded at Graigueshoneen (Tierney 2005), Rathpatrick (site 17) (Wren 2006b) and Scart (Monteith 2011), though evidence for settlement or agricultural activity is sorely lacking for this period in the archaeological record.

5.5. Conclusion.

The results of detailed palynological investigations reported here demonstrate strong evidence for farming during the Neolithic at Lough Cullin. The date for the mid-Holocene 'Elm Decline' at Lough Cullin again questions the reliability of the general ascribed date of *c.*4000 cal BC for this 'event'. The palynological record exhibits a distinct *Landnam* phase which is strongly expressed by a substantial reduction in arboreal pollen and corresponds with an increase in the non-arboreal pollen component. This well-dated profile demonstrates that the *Landnam* involved sustained farming activity over several centuries and considering the duration and scale of the *Landnam* event, permanent settlement rather than a shifting agricultural regime is envisaged. The level of woodland openness and the palynological signal for cereal cultivation infers that an early farming community must have existed in the vicinity of the sampling site. The pollen evidence indicates a pastoral-based agricultural was practiced, however, it is clear that cereal cultivation also constituted an element of Early Neolithic agrarian economy of the region. The identification of cereal pollen in addition to the radiocarbon dated macrofossil evidence from archaeological contexts suggest that this arable farming was centred on the centuries follow the mid-Holocene 'Elm Decline'.

The level of Early Neolithic anthropogenic activity around Lough Cullin was not sustained and the profile clearly demonstrates a prolonged period of woodland regeneration, facilitated by low levels of farming and possibly complete abandonment of agriculture in the region. This suggest that Neolithic activity, at least in the vicinity of the sampling site, was confined to the earlier half of the fourth millennium cal BC. This is mirrored in the archaeological record of the region which exhibits a boom of settlement activity between *c.*3750 cal BC and *c.*3550 cal BC. The distinct lull in anthropogenic activity lasts untilthe Late Neolithic, when agricultural activity was renewed, but with a lower intensity compared with the Early Neolithic phase.

Chapter 6 - Palaeoenvironmental analysis from Arderrawinny, County Cork.

6.1. Introduction.

The previous chapter has outlined the palaeoecological evidence for the vegetation history, woodland disturbance and potential anthropogenic activity at Lough Cullin in the south-east of the study site. In this chapter the results from the palaeoecological investigations at Arderrawinny are presented and the relationship between Holocene vegetation, the local environmental conditions, human impacts and regional vegetation changes are examined and interpreted. The chronology of palynological 'events' often associated with the adoption of Neolithic agriculture are outlined in this chapter but are considered in greater detail in **Chapter 7**. Finally, the implications of this palaeoenvironmental analysis on the understanding of ecological change, woodland development and the timing and intensity of Early Neolithic agriculture in the region are discussed in **Chapter 8.** For methodologies and site information see **Chapter 2**.

6.2. Results.

6.2.1. Stratigraphy.

The stratigraphy of the uppermost 7cm consisted of dry reddish/brown moderately humified peat with vertical rootlets through it. No samples was recovered between 7cm and 38cm due the wet nature of the sediment between these depths. The sediment between 38cm and 165cm consisted of a homogenous, dark brown well-humified herbaceous peat with occasional *Phragmites* (reeds) and wood fragments. This transitions into a lighter brown-orange *Sphagnum* peat between 165 cm and 173cm followed by a return to dark brown well-humified herbaceous peat between 173cm and 212cm. This transitioned to a black, fibrous, well-humified peat with fragments of monocotyledonous leaves between 212cm and 265cm. A band of dark brown, well humified *Sphagnum* peat was recorded between 265cm and 271cm. Between 271cm and 512cm the sediment consisted of a black, fibrous peat with twigs occurring sporadically towards the base of the core. Also identified within this section of the core were the seeds of *Scirpus (cf.) Schoenoplectus* *lacustris* (Common club-rush) and *Vaccinium (cf.) oxycoccos* (bog cranberry) [3]. The basal 9cm of the core is a greyish-blue sandy *gyttja*. As pollen preservation and concentration values were very low in this basal 9cm only the upper 512cm of the core were analysed in detail.

Depth (cm)	Troels-Smith Description	Sediment Description
0 – 7	nig 2; strf 2; elas 3; sicc 1; hum 1	Reddish - brown moderately humified peat with vertical rootlets.
7 – 38	No Sample	
38 – 165	nig 3; strf 0; elas 3; sicc 3; lim 1; hum 3	Dark brown well humified peat with *Phragmites* (reeds) and wood fragments
165 – 173	nig 2; strf 0; elas 2; sicc 3; lim 0; hum 3	Light brown/orange *Sphagnum* peat
173 – 212	nig 3; strf 0; elas 3; sicc 3; lim 1; hum 3	Dark brown well humified peat with *Phragmites* (reeds) and wood fragments
212 – 265	nig 4; strf 0; elas 1; sicc 2; lim 0; hum 3	Black, well humified fibrous peat.
265 – 271	nig 3; strf 0; elas 2; sicc 3; lim 0; hum 3	Dark brown well humified *Sphagnum* peat
271 – 512	nig 4; strf 0; elas 1; sicc 2; lim 0; hum 3	Black, well humified fibrous peat with occasional seeds and wood fragments
512 – 526	nig 2; strf 0; elas 3; sicc 3; lim 3; hum 3	Greyish/blue *gyttja*

Table 6.1 Summary of Troels-Smith sediment description for Arderrawinny

[3] Macro-fossil analysis undertaken by Dr Susan Lyons, Department of Archaeology, University College Cork.

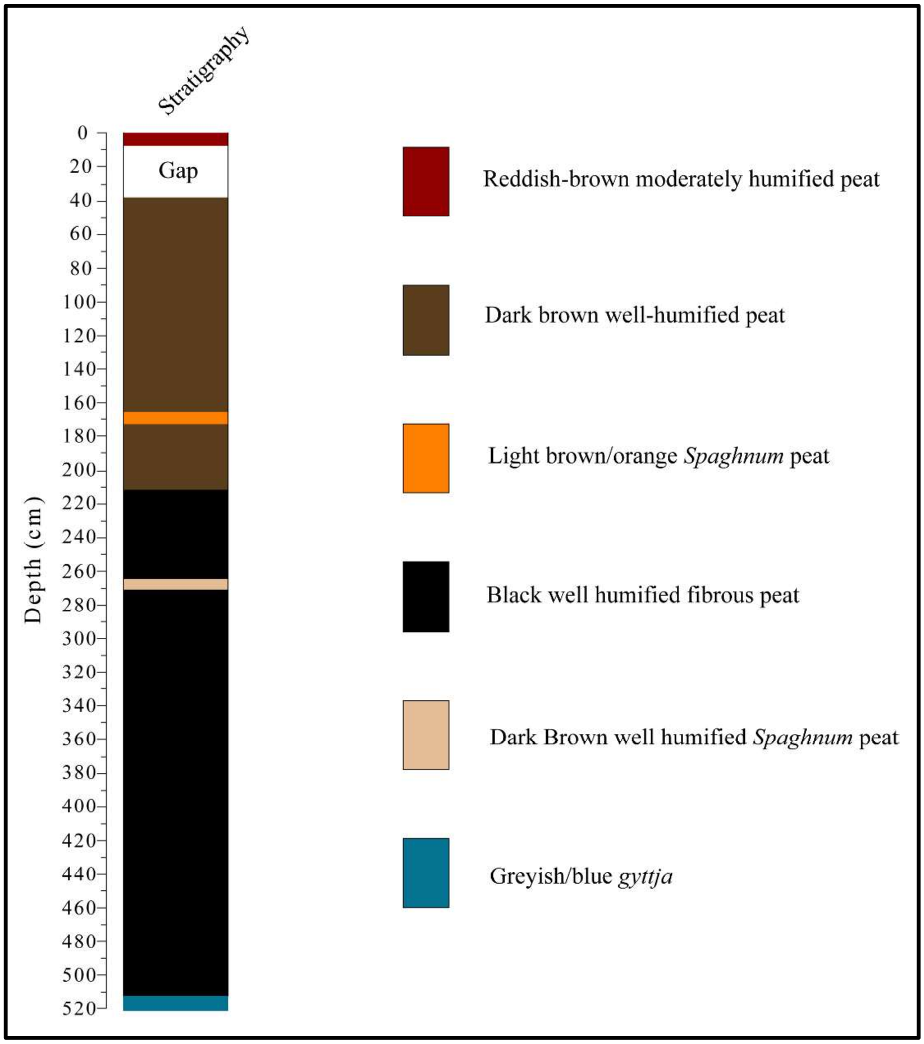

Figure 6.1 Stratigraphic record of palaeoenvironmental core from Arderrawinny (ARD)

6.2.2. Chronology.

A total of twelve radiocarbon measurements were obtained for this sequence (see Table 6.2). Two radiocarbon measurements were obtained on macrofossils, *Vaccinium (cf.) oxycoccos* (bog cranberry) and *Scirpus (cf.) Schoenoplectus lacustris* (common club-rush) seeds, and two were obtained from humin fraction from a 1cm³ bulk peat sample. A further eight paired radiocarbon measurements were obtained on true replicates of different chemical fractions (humic acid and humin fractions) from four 1cm³ bulk peat samples. The statistical consistency of these four paired radiocarbon measurements was assessed (Ward and Wilson 1978) (see Table 6.3), with only the paired radiocarbon measurements *UBA-33012* and *UBA-33013*, from a depth of 417cm, shown to be statistically inconsistent (T'=5.7; T'(5%)=3.8; v=1) (*ibid.*) and were therefore estimated to not be coeval.

The age-depth model (not shown, see Appendix C 2.1) had good overall agreement ($A_{overall}$=94.6) when all measurements were included but given the statistical inconsistency from the paired radiocarbon measurements from 417cm, the humic measurement has been excluded. Humic acids are water-soluble and therefore are potentially able to move up or down through the profile, which may have caused the resulting humin and humic fraction radiocarbon determinations to not be coetaneous (Brock *et al.* 2011, 552). The age-depth model (Bronk Ramsey 2008; Bronk Ramsey and Lee 2013) is therefore constructed using the combined measurements from 230cm, 344cm and 444cm, the two macrofossil measurements (294cm and 342cm) and the humin measurement from 94 cm, 321cm and 417cm. This age depth model has good overall agreement ($A_{overall}$=89.0) and is believed to be robust (For model specifications see Appendix C 2.2). Analysis of all dates incorporated into the model determined that no outlier existed (see Appendix C 2.3).

This age-depth model has been used to calculate deposition rates for the profile, provide a *posterior density estimate* for pollen assemblage zones (PAZ) (see Table 6.4) and also for the mid-Holocene 'Elm Decline', the initiation of the continuous *Plantago lanceolata* curve and other palynological features from the profile. The sequence is estimated to cover 5*480 – 9280 years,* comprising much of the Holocene from the Early Mesolithic to the Late Bronze Age. Estimates derived from the age-depth model suggest an average accumulation rate of 6 – *7cm/100 years* between the upper and basal radiocarbon measurements or alternatively *14 – 17 years* are represented in every centimetre. (For *P_Sequence* deposition model specifications see Appendix C 2.4).

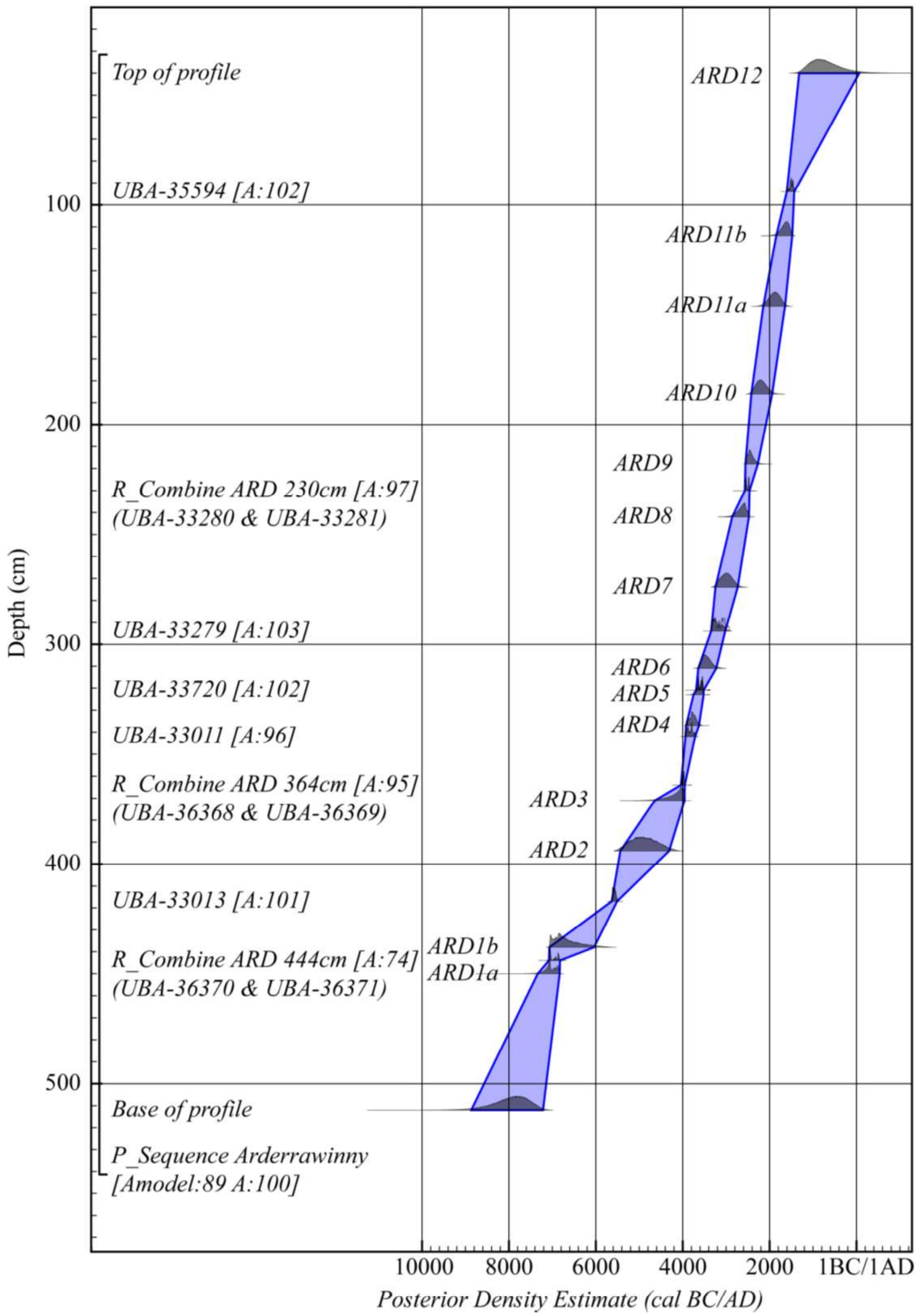

Figure 6.2 Bayesian age-model of the chronology of the sediment sequence at Arderrawinny (P_Sequence model (k=0.01-100) (Bronk Ramsey 2008; Bronk Ramsey and Lee 2013) Blue band showing the estimated date of sediment at the corresponding depth at 95.4% probability.

Lab Code	Depth (cm)	Dated Material	Radiocarbon Age (years BP)	Calibrated Age (2δ) 95.4% Probability	Calibrated Age (1δ) 68.2% Probability
UBA-35534	94 – 95	Peat (humin fraction)	3237±28	1609 – 1580 cal BC (11.3%) 1563 – 1438 cal BC (84.1%)	1595 – 1589 cal BC (3.2%) 1532 – 1492 cal BC (40.8%) 1483 – 1452 cal BC (24.2%)
UBA-33280	230 – 231	Peat (humic fraction)	4017±33	2620 – 2469 cal BC	2572 – 2511 cal BC (53.1%) 2506 – 2488 cal BC (15.1%)
UBA-33281	230 – 231	Peat (humin fraction)	3933±32	2562 – 2493 cal BC (5.2%) 2493 – 2335 cal BC (87.1%) 2324 – 2306 cal BC (3.1%)	2477 – 2431 cal BC (32.4%) 2425 – 2401 cal BC (14.7%) 2381 – 2348 cal BC (21.1%)
UBA-33279	294 – 295	*Schoenoplectus (cf.) lacustris* (seed)	4450±47	3339 – 3205 cal BC (38.0%) 3197 – 3007 cal BC (49.8%) 2988 – 2931 cal BC (7.6%)	3327 – 3175 cal BC (32.6%) 3175 – 3160 cal BC (4.1%) 3120 – 3023 cal BC (31.6%)
UBA-33720	321 – 322	Peat (humin fraction)	4817±44	3696 – 3518 cal BC	3652 – 3629 cal BC (21.7%) 3584 – 3531 cal BC (46.5%)
UBA-33011	342 – 343	*Vaccinium (cf.) oxycoccos* (Seed)	5031±32	3946 – 3760 cal BC (89.4%) 3742 – 3714 cal BC (6.0%)	3938 – 3867 cal BC (45.5%) 3812 – 3774 cal BC (22.7%)
UBA-36368	364 – 365	Peat (humic fraction)	5207±37	4224 – 4208 cal BC (1.8%) 4160 – 4132 cal BC (3.8%) 4070 – 3955 cal BC (89.8%)	4041 – 4011 cal BC (33.5%) 4005 – 3974 cal BC (34.7%)
UBA-36369	364 – 365	Peat (humin fraction)	5139±34	4038 – 4019 cal BC (4.3%) 3997 – 3924 cal BC (60.3%) 3877 – 3804 cal BC (30.9%)	3985 – 3941 cal BC (49.8%) 3857 – 3819 cal BC (18.4%)
UBA-33012	417 – 418	Peat (humic fraction)	6788±49	5754 – 5620 cal BC	5718 – 5646 cal BC
UBA-33013	417 – 418	Peat (humin fraction)	6642±37	5632 – 5510 cal BC	5620 – 5550 cal BC
UBA-36370	444 – 445	Peat (humic fraction)	8059±38	7138 – 7100 cal BC (4.7%) 7086 – 6904 cal BC (73.9%) 6888 – 6827 cal BC (16.8%)	7079 – 7027 cal BC (50.5%) 6958 – 6954 cal BC (1.0%) 6932 – 6919 cal BC (4.5%) 6878 – 6845 cal BC (12.2%)
UBA-36371	444 – 445	Peat (humin fraction)	8051±47	7141 – 6806 cal BC (95.2%) 6783 – 6780 cal BC (0.2%)	7078 – 7021 cal BC (34.4%) 6969 – 6944 cal BC (7.7%) 6938 – 6914 cal BC (8.5%) 6882 – 6836 cal BC (17.5%)

Table 6.2 Radiocarbon dates for core ARD (Arderrawinny). Radiocarbon dates were calibrated using the datasets published by Reimer et al. (2013) and the computer program OxCal 4.3 (Bronk Ramsey 1995; 1998; 2001; 2009).

Lab Code	Depth (cm)	R_Date	R_Combine Date	T' Value	R_Combine Calibrated Age (2δ) 95.4% Probability	R_Combine Calibrated Age (1δ) 68.2% Probability
UBA-33280	230-231	4017±33	3974±23	T'=3.3; T'(5%) =3.8; v=1	*2570 – 2515 cal BC (48.1%)* *2501 – 2462 cal BC (47.3%)*	*2559 – 2536 cal BC (29.8%)* *2491 – 2469 cal BC (38.4%)*
UBA-33281	230-231	3933±32				
UBA-36368	364-365	5207±37	5170±26	T'=1.8; T'(5%)=3.8; v=1	*4041 – 4012 cal BC (19.5%)* *4005 – 3951 cal BC (75.9%)*	*4032 – 4029 cal BC (2.8%)* *3991 – 3659 cal BC (65.4%)*
UBA-36369	364-365	5139±34				
UBA-33012	417-418	6788±49	6696±33	T'=5.7; T'(5%)=3.8; v=1	*5666 – 5556 cal BC*	*5641 – 5613 cal BC (45.5%)* *5588 – 5567 cal BC (22.7%)*
UBA-33013	417-418	6642±37				
UBA-36370	444-445	8059±38	8056±30	T'=0.0; T'(5%)= 3.8; v=1	*7083 – 6982 cal BC (69.9%)* *6975 – 6911 cal BC (11.2%)* *6885 – 6830 cal BC (14.3%)*	*7074 – 7029 cal BC (63.5%)* *6875 – 6864 cal BC (4.7%)*
UBA-36371	444-445	8051±47				

Table 6.3 Weighted mean using R_Combine() function in OxCal 4.3 (Bronk Ramsey 1995; 1998; 2001; 2009).

Parameter	Top Depth (cm)	*P_Sequence* 2δ Posterior Density Estimate (95.4%) PAZ top	*P_Sequence* 1δ Posterior Density Estimate (68.2%) PAZ top
Top of Profile/ARD12	40	*1320 cal BC – 70 cal AD*	*1150 – 480 cal BC*
ARD11b	114	*1850 – 1480 cal BC*	*1720 – 1530 cal BC*
ARD11a	146	*2150 – 1640 cal BC*	*2010 – 1740 cal BC*
ARD10	186	*2430 – 1940 cal BC*	*2330 – 2080 cal BC*
ARD9	218	*2560 – 2270 cal BC*	*2530 – 2390 cal BC*
ARD8	242	*2870 – 2470 cal BC*	*2720 – 2520 cal BC*
ARD7	274	*3250 – 2730 cal BC*	*3150 – 2860 cal BC*
ARD6	311	*3650 – 3220 cal BC*	*3570 – 3360 cal BC*
ARD5	323	*3760 – 3510 cal BC*	*3670 – 3620 cal BC (23.3%)* *3610 – 3530 cal BC (44.9%)*
ARD4	337	*3930 – 3620 cal BC*	*3880 – 3850 cal BC (5.9%)* *3840 – 3690 cal BC (62.3%)*
ARD3	371	*4650 – 3950 cal BC*	*4250 – 3960 cal BC*
ARD2	394	*5550 – 4200 cal BC*	*5380 – 4560 cal BC (67.5%)* *4550 – 4540 cal BC (0.7%)*
ARD1b	438	*7070 – 6040 cal BC*	*7060 – 6560 cal BC*
ARD1a	450	*7340 – 6830 cal BC*	*7150 – 7030 cal BC (37.8%)* *6980 – 6850 cal BC (30.4%)*
Bottom of Profile	512	*8870 – 7210 cal BC*	*8250 – 7460 cal BC*

Table 6.4 Posterior Density Estimate for top & bottom of profile and the PAZs from Arderrawinny

6.2.3. Pollen.

PAZ/ Depth (cm)	PAZ top PDE	Main features
ARD12 (40-114)	*1320 cal BC-70 cal AD*	NAP values increase further to *c.*33%. *Salix* values increase to peak levels (*c.*11%) at the top of the PAZ, while *Calluna* values also continue to decrease to *c.*5%. There is a further increase in Cyperaceae to *c.*39% and wetland NAP taxa, Lamiaceae, *Filipendula* and *Potentilla*-type throughout the PAZ.
ARD11b (114-146)	*1850-1480 cal BC*	Reduced *Calluna vulgaris* values to *c.*17% from the base of the PAZ while there is an increase in Cyperaceae from 13 to *c.*22% and peak values of *Sphagnum* spp. (*c.*105%). Considerable increase in NAP (10 to *c.*26%) in addition to the sporadic occurrence of *Plantago lanceolata, Filipendula, Potentilla*-type, *Rumex*, Ranunculaceae, Apiaceae and Asteraceae.
ARD11a (146-186)	*2150-1640 cal BC*	*Calluna vulgaris* values peak at *c.*36%, while *Corylus* values are reduced to 35%. Final reduction in *Pinus*. Low initial *Sphagnum* spp. values (*c.*7%), but steadily increasing throughout the PAZ, while *Osmunda regalis* values decline to *c.*11%. NAP values remain stable at between 10 and *c.*14%, but *Cerealia*-type pollen is recorded.
ARD10 (186-218)	*2430-1940 cal BC*	Major decline of *Pinus* values to *c.*6%, while *Corylus* values increase to peak values of *c.*51%. Increased *Calluna vulgaris* (*c.*7 to *c.*18%) is recorded at the top of the PAZ while Cyperaceae (to *c.*7%) and *Sphagnum* spp. (to 6%) values are reduced.

PAZ/ Depth (cm)	PAZ top PDE	Main features
ARD9 (218-242)	*2560-2270 cal BC*	*Pinus* values are reduced to 26% while *Betula* and NAP values increase to 10% and to *c*.22%, *Cerealia*-type pollen is recorded. A continuous presence of *Calluna vulgaris* (*c*.7%) begins, Cyperaceae values fluctuate between *c*.15 and *c*.20% while there is a large increase in *Osmunda regalis* to *c*.46% and *Sphagnum* spp. from *c*.9 to *c*.63%.
ARD8 (242-274)	*2870-2470 cal BC*	*Pinus* values fluctuate between *c*.35 and *c*.51%, while values of *Quercus* (*c*.2 to 7%)*, Betula* (*c*.2 to *c*.4%) and *Corylus* (*c*.12 to 16%) increase. Cyperaceae increases considerably to 35% at the base of the PAZ and high *Osmunda regalis* values of between *c*.25 and *c*.35% are recorded throughout the PAZ.
ARD7 (274-311)	*3250-2730 cal BC*	*Pinus* values recover at the base of this PAZ (*c*.38 to 61%), while *Quercus*(8 to 2%)*, Betula* (6 to 2%) and *Corylus* (12 to 6%) values are reduced. NAP values also decline to 15%. Continuous presence of *Plantago lanceolata* ceases, although it is still recorded less frequently at the top of the PAZ. Cyperaceae increases to 14% and *Osmunda regalis* values rise from *c*.4 to 20% mid-way through the PAZ, while *Filipendula, Potentilla*-type, *Digitalis* and Lamiaceae are sporadically present across the PAZ.
ARD6 (311-323)	*3650-3220 cal BC*	AP values (81 to 53%), especially *Pinus* (69 to *c*.38%)*,* are reduced. However, increases in *Corylus* (*c*.7 to 12%) and *Betula* (*c*.7 to 10%) are also recorded. NAP (*c*.7 to *c*.21%), especially Poaceae (*c*.7 to *c*.18%), increase considerably throughout the PAZ, while peak values of *Plantago lanceolata* (3%) are also recorded mid-way through the PAZ. Cyperaceae also begins to increase from the base of this PAZ (*c*.3 to 11%).

PAZ/ Depth (cm)	PAZ PDE	Main features
ARD5 (323-337)	*3810-3520 cal BC*	Reduced NAP values (*c*.15 to *c*.7%) exhibited for much of the PAZ, with most pronounced reduction in values of Poaceae (*c*.12 to *c*.7%). However, *Plantago lanceolata* is recorded continuously while *Filipendula,* Apiaceae, *Rumex*, Ranunculaceae and Asteraceae are occasionally noted throughout the PAZ. AP values greatly increased (*c*.68 to 81%), especially *Pinus* (47 to 69%) however values of *Quercus* (15 to 5%) and *Corylus* (14 to 10%) decline. *Ulmus* values greatly reduced at the base of the PAZ and cease to be recorded after the initial two spectra.
ARD4 (337-371)	*3930-3620 cal BC*	Increased NAP values (12 to 24%), primarily Poaceae (11 to 21%), throughout this PAZ. A continuous presence of both *Plantago lanceolata* and *Filipendula* is recorded in addition to more frequent occurrences of Apiaceae, *Artemisia, Rumex* and *Urtica*. *Quercus* values remain stable at *c*.14% while *Pinus* (*c*.57 to 40%) values are reduced. *Corylus* values increase to 20% mid-way through the PAZ, before declining to 14% towards the top . *Ulmus* is present throughout, but at low values, while *Alnus* is recorded more frequently.
ARD3 (371-394)	*4650-3950 cal BC*	High values of *Pinus* (*c*.50%) throughout the PAZ. *Corylus* (*c*.13%), *Quercus* (*c*.11%), *Betula* (*c*.3%) and NAP (*c*.13%) values remain relatively stable, while values of Cyperaceae increase marginally across the PAZ from *c*.3 to *c*.6%. *Plantago lanceolata* and Asteraceae recorded more frequently at top of PAZ.

PAZ/ Depth (cm)	PAZ PDE	Main features
ARD2 (394-438)	*5540-4310 cal BC*	*Pinus* values increase (9 to 44%) across the PAZ, while values of *Corylus* (37 to 16%), *Quercus* (30 to 16%) and *Betula* (6 to 3%) are reduced. *Ulmus* is recorded throughout but values remain low (*c.*1%). *Alnus, Ilex, Sambucus* and *Rhamnus* occasionally noted in PAZ. Continuous presence of *Salix, Calluna* and *Hedera,* although *Hedera* less frequent at the top of the PAZ. NAP values remain stable at between 12 and 15%. *Cerealia*-type pollen is recorded for the first time in the profile.
ARD1b (438-450)	*7070-6040 cal BC*	Brief decline in *Corylus* (31 to 14%) and to a lesser extent *Quercus* (35 to 24%) mid-way through the sub-PAZ, with corresponding increased values of *Pinus* (5 to 30%) noted. After which values of *Corylus* recover to 38% and *Pinus* values decline to 9%. Values of other AP (*c.*73%) and NAP (*c.*14%) taxa remain relatively stable throughout.
ARD1a (450-512)	*7340-6830 cal BC*	Sub-PAZ characterised by high values of *Corylus* (30-42%) and *Quercus* (20-40%), *Betula* (5-14%) and *Pinus* (3-13%) are also represented throughout the sub-PAZ. *Ulmus* is present but values fluctuate between 1-5%, *Alnus, Fraxinus, Taxus* and *Carpinus* recorded sporadically. Continuous presence of *Ilex, Hedera* and *Salix*, although *Ilex* ceases to be identified towards the top of the sub-PAZ. NAP values between 10-15%, sporadic occurrence of *Plantago lanceolata, Filipendula, Potentilla*-type, *Rumex*, Ranunculaceae and Asteraceae.

Table 6.5 Summary of pollen data from Arderrawinny (ARD).

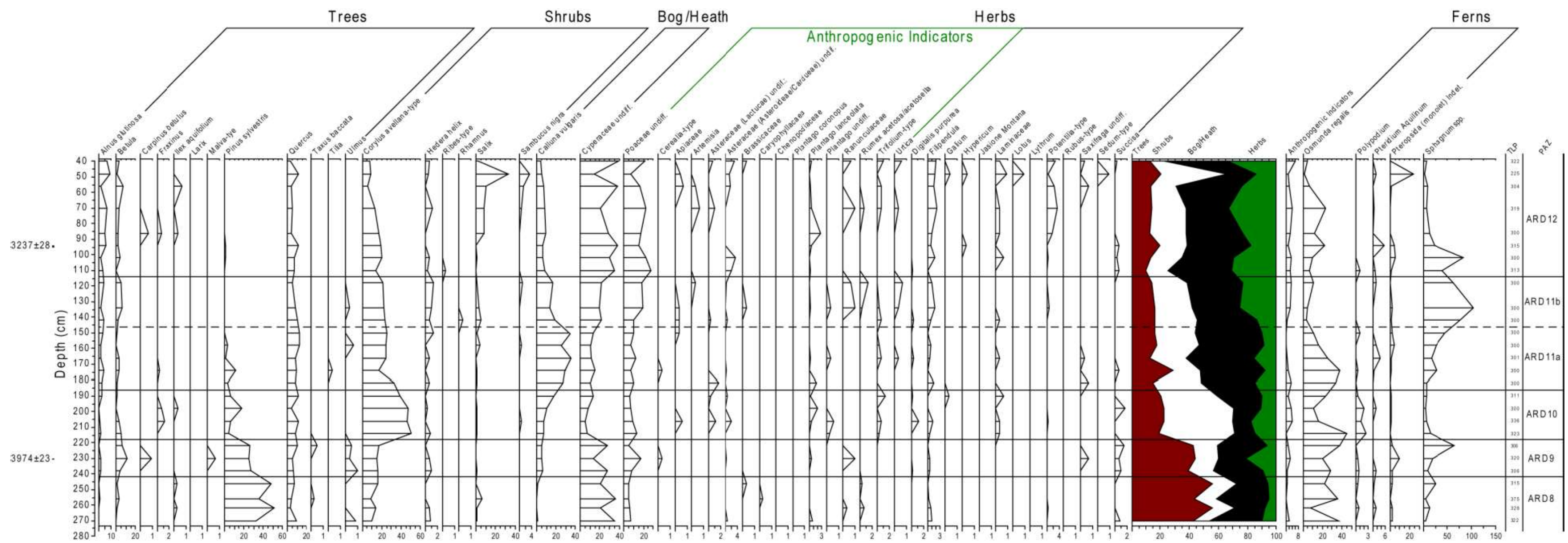

Figure 6.3 Pollen percentage diagram for profile ARD (PAZs ARD8-12)

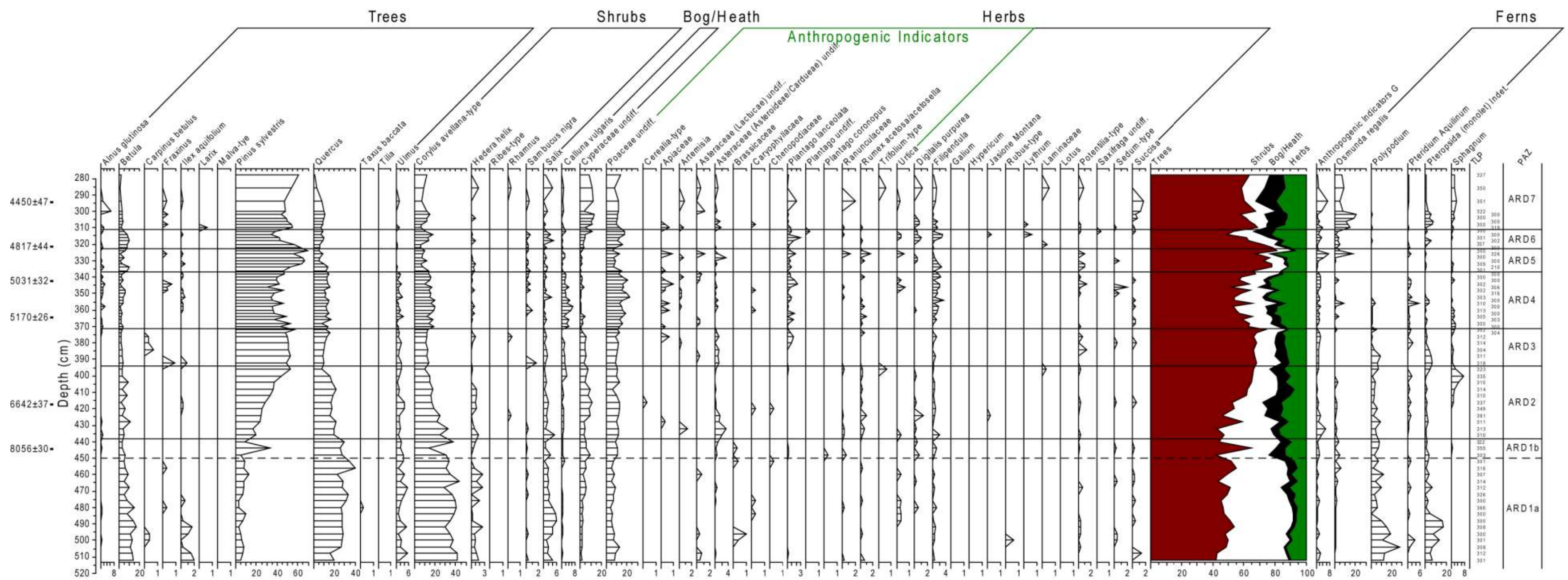

Figure 6.4 Pollen percentage diagram for profile ARD (PAZs ARD1-7)

PAZ/ Depth (cm)	PAZ top PDE	Pollen Concentration
ARD12 (40-114)	*1320 cal BC-70 cal AD*	The PAZ opens with TLP concentrations of 171×10^3 cm^{-3}, increasing to 255×10^3 cm^{-3} by 70cm, before declining to 61×10^3 cm^{-3} at the top of the PAZ. All taxa exhibit a similar pattern across the PAZ, although both Herb and Bog/Heath pollen concentration increases between 48cm and 40cm, while total tree and shrub concentration decreases. Herbs from 11×10^3 cm^{-3} to 20×10^3 cm^{-3}, Bog/Heath from 16×10^3 cm^{-3} to 27×10^3 cm^{-3}. This is primarily reflected in increased concentrations of Poaceae (5×10^3 cm^{-3} to 13×10^3 cm^{-3}) and Cyperaceae (11×10^3 cm^{-3} to 24×10^3 cm^{-3})
ARD11b (114-146)	*1850-1480 cal BC*	TLP concentration increases throughout this sub-PAZ, rising from 260×10^3 cm^{-3} to 329×10^3 cm^{-3} by the end of the sub-PAZ. Total herb pollen concentration increase from 35×10^3 cm^{-3} to 75×10^3 cm^{-3}, primarily related to an increase in Poaceae from 26×10^3 cm^{-3} to 61×10^3 cm^{-3}, while there is only a moderate increase in concentration of both trees (42×10^3 cm^{-3} to 46×10^3 cm^{-3}) and shrubs (76×10^3 cm^{-3} to 81×10^3 cm^{-3}). Despite an overall increase in TLP concentration, Bog/Heath concentration declines at 134cm (from 105×10^3 cm^{-3} to 96×10^3 cm^{-3}) before an increase to 126×10^3 cm^{-3} by the end of the PAZ.

PAZ/ Depth (cm)	PAZ top PDE	Pollen Concentration
ARD11a (146-186)	*2150-1640 cal BC*	TLP concentration decreases from $297x10^3$ cm^{-3} to $189x10^3$ cm^{-3} between 182cm and 174cm, before increasing to $202x10^3$ cm^{-3} at 166cm. This is exhibited across all taxa except trees which increase from $43x10^3$ cm^{-3} to $54x10^3$ cm^{-3} across the same spectra. All taxa increase in concentration at 166cm except trees which decrease to $25x10^3$ cm^{-3}. This pattern is primarily related to increased concentration of *Pinus* which increases from $10x10^3$ cm^{-3} to $22x10^3$ cm^{-3} between 182cm and 174cm before decreasing to $1x10^3$ cm^{-3} at 166cm. TLP concentration continues to increase for the remained of the sub-PAZ, while herb concentration, in contrast with all other taxa, decreases from $31x10^3$ cm^{-3} to $24x10^3$ cm^{-3} by the top of the sub-PAZ, although Poaceae concentration remains relatively stable at $25x10^3$ cm^{-3}.
ARD10 (186-218)	*2430-1940 cal BC*	TLP concentration increases from $269x10^3$ cm^{-3} at the base of the PAZ to $636x10^3$ cm^{-3} at 206cm and this pattern is exhibited across all taxa. TLP concentration declines to $329x10^3$ cm^{-3} by 198cm, although the reduction in Bog/Heath taxa concentration is minimal ($77x10^3$ cm^{-3} to $60x10^3$ cm^{-3}) in contrast to trees ($141x10^3$ cm^{-3} to$73x10^3$ cm^{-3}), shrubs ($303x10^3$ cm^{-3} to $159x10^3$ cm^{-3}) and herbs ($113x10^3$ cm^{-3} to $36x10^3$ cm^{-3}). TLP concentration continues to increase to $381x10^3$ cm^{-3} by the top of the PAZ, however, this increase is primarily related to increased Bog/Heath taxa concentration which increases to $116x10^3$ cm^{-3}. This is contrast to only marginal increase in trees, to $78x10^3$ cm^{-3}, and herbs, to $38x10^3$ cm^{-3}, while shrubs decrease to $148x10^3$ cm^{-3}.

PAZ/ Depth (cm)	PAZ top PDE	Pollen Concentration
ARD9 (218-242)	*2560-2270 cal BC*	TLP concentration increases from $425x10^3$ cm^{-3} at the base of the PAZ to $606x10^3$ cm^{-3} at 230cm, this increase is most pronounced in values of Poaceae ($31x10^3$ cm^{-3} to $106x10^3$ cm^{-3}) and *Betula* ($16x10^3$ cm^{-3} to $68x10^3$ cm^{-3}), while overall values for Bog/Heath pollen concentration decline from $144x10^3$ cm^{-3} to $118x10^3$ cm^{-3} over the same spectra.
ARD8 (242-274)	*2870-2470 cal BC*	Concentration values remain relatively stable throughout this PAZ.
ARD7 (274-313)	*3250-2730 cal BC*	Concentration values remain relatively stable throughout this PAZ.
ARD6 (311-323)	*3650-3220 cal BC*	TLP concentration values decline from $416x10^3$ cm^{-3} at the top of the previous PAZ to $235x10^3$ cm^{-3} at 320cm. This reduction is noted across all taxa except herbs which increase from $30x10^3$ cm^{-3} to $39x10^3$ cm^{-3} across the same spectra. A further decline in TLP concentrated is recorded at 318cm to $153x10^3$ cm^{-3}, however this decline is not exhibited in values for shrubs which increase from $16x10^3$ cm^{-3} to $30x10^3$ cm^{-3} between 320cm and 318cm. From 316cm all taxa exhibit an increase in concentration values throughout the rest of the PAZ. This increase at 230cm is followed by a sharp reduction in TLP concentration at 222cm which is recorded across all taxa.

PAZ/ Depth (cm)	PAZ top PDE	Pollen Concentration
ARD5 (323-337)	*3810-3520 cal BC*	TLP concentration values decline from 446x10^3 cm^{-3} at the top of the previous PAZ to 330x10^3 cm^{-3} at the base of PAZ ARD5 to 190x10^3 cm^{-3} at 334cm. A similar pattern is exhibited across all taxa with the exception of *Betula*, which increases from 14x10^3 cm^{-3} at 338cm to 25x10^3 cm^{-3} at 336cm. TLP concentration values increase continuously between 332cm (306x10^3 cm^{-3}) and 326cm (566x10^3 cm^{-3}), this is most pronounced in concentration values for herbs (35x10^3 cm^{-3} to 125x10^3 cm^{-3}) and trees (239x10^3 cm^{-3} to 382x10^3 cm^{-3}) while shrubs values remain stable.
ARD4 (337-371)	*3810-3520 cal BC*	TLP concentration increases from 367x10^3 cm^{-3} at the base of the PAZ to 1059x10^3 cm^{-3} at 364cm before declining to 347x10^3 cm^{-3} at 358cm and remaining relatively stable for the remained of the PAZ. This increase is primarily recorded in values of *Pinus* (264x10^3 cm^{-3} to 517x10^3 cm^{-3}), Poaceae (92x10^3 cm^{-3} to 163x10^3 cm^{-3}) and Cyperaceae (9x10^3 cm^{-3} to 45x10^3 cm^{-3}) between 366cm and 364cm. Despite this increase in TLP concentration values for *Corylus* and *Quercus* remain stable over the same spectra.
ARD3 (371-394)	*3930-3620 cal BC*	A marked decrease in TLP concentration is noted at the base of this PAZ, with values declining from 1122x10^3 cm^{-3} at the top of the previous PAZ to 263x10^3 cm^{-3}. This reduction is noted across all taxa. A sharp increase in TLP concentration is recorded from 376cm, with values increasing to 813x10^3 cm^{-3} and continuing to increase to 1049x10^3 cm^{-3} by the top of the PAZ. This is again noted across all taxa with the greatest increase being in values of *Pinus* which in increase from 139x10^3 cm^{-3} at 380cm to 403x10^3 cm^{-3} and 590x10^3 cm^{-3} across the same spectra.

PAZ/ Depth (cm)	PAZ top PDE	Pollen Concentration
ARD2 (394-438)	*4650-3950 cal BC*	A sharp increase in TLP concentration is recorded at the start of the PAZ to $1615x10^3$ cm^{-3}, this is recorded across all taxa with the most pronounced increase noted in vales of *Corylus* ($76x10^3$ cm^{-3} to $406x10^3$ cm^{-3}), *Pinus* ($17x10^3$ cm^{-3} to $317x10^3$ cm^{-3}) and *Quercus*, which despite decreasing to percentage values, increases in concentration values from $58x10^3$ cm^{-3} to $323x10^3$ cm^{-3}.
ARD1b (438-450)	*5540-4310 cal BC*	TLP concentration continues to decline from the start of this PAZ reaching $170x10^3$ cm^{-3} by 444cm. Despite the overall reduction in pollen concentration this reduction is most pronounced in shrub taxa which decreases from $58x10^3$ cm^{-3} at the bottom of the PAZ to $26x10^3$ cm^{-3} at 444cm, while total tree pollen concentration increases from $72x10^3$ cm^{-3} to $111x10^3$ cm^{-3}. This is primarily related to a reduction of *Corylus avellana*-type from $52x10^3$ cm^{-3} to $23x10^3$ cm^{-3} and an increase in *Pinus* concentration from $8x10^3$ cm^{-3} to $56x10^3$ cm^{-3} over the same spectra. TLP concentration increases again to $201x10^3$ cm^{-3} at 440cm, although tree pollen concentration decreases to $88x10^3$ cm^{-3}. This is primarily attributable to a reduction in *Pinus* concentration to $16x10^3$ cm^{-3}.
ARD1a (450-512)	*7070-6040 cal BC*	The profile opens with TLP concentration at $298x10^3$ cm^{-3}, before increasing to $382x10^3$ cm^{-3} at 508cm. Thereafter, TLP concentration remains relatively stable until 484cm when it declines to $195x10^3$ cm^{-3}. This reduction is recorded across all taxa. TLP concentration recovers to $416x10^3$ cm^{-3} by 476cm and remains relatively stable until 452cm where it declines sharply to $196x10^3$ cm^{-3}. This is again recorded across all taxa.

Table 6.6 Summary of pollen concentration data from Arderrawinny (ARD)

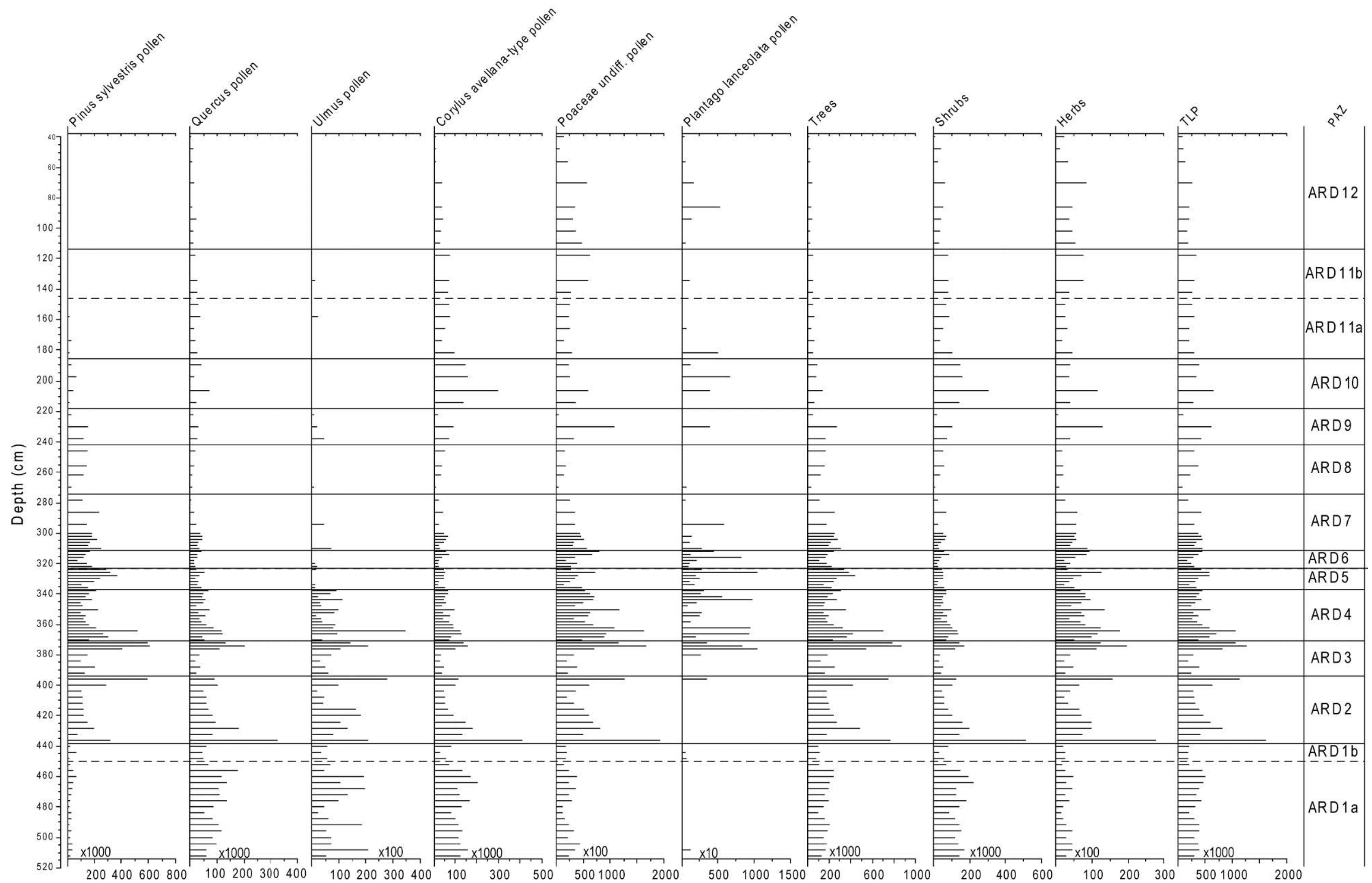

Figure 6.5 Pollen concentration data for selected taxa from Arderrawinny (ARD)

6.2.4. Detrended Correspondence Analyses

The results of the DCA (taxa scores only) are presented in Figure 6.6. Axis 1 accounts for 0.37 of the variation and may represent a hydrological gradient with increasing taxa scores reflecting vegetation typical of wetter soils. **Dry Woodland** taxa such as *Pinus, Ulmus* and *Ilex* plot towards the left while **Bog/Heath** taxa such as *Sphagnum* are plotted towards the right of the axis. Axis 2 can be recognised a gradient between woodland environments and open habitats, but this axis accounts for only 0.13 of the variation. A distinct group of trees and shrubs can be recognised towards the top of the plot, with herbs and associated open ground plants plotting towards the base of Axis 2. An exception to this is *Pinus* which plots towards the base of Axis 2.

The broad group of tree and shrub species can be further separated into discrete groups: *Ulmus, Betula, Quercus* and *Ilex* forming one broadleaf group and *Corylus, Hedera helix* and *Salix* forming a **Scrub Woodland** group. It can also be observed that the spore *Polypodium* plots within this broadleaf group, suggesting it grew as an epiphyte, while *Pteridium* plots within the latter group which suggests a degree of openness to this scrub woodland. *Alnus* plots towards the centre of the plot and may indicate the presence of a **Carr Woodland**.

Herbs typical of **Open Environments** form a distinct group to the base of Axis 2, with a cluster of taxa within this consisting of *Plantago lanceolata* and Apiaceae. This group includes predominantly low growing heliophytes commonly found growing together in pastoral/meadow vegetation. Around the edges of this grouping the herbs *Filipendula*, *Rumex,* Poaceae and Asteraceae are located, possibly differentiating taller herb vegetation found on less disturbed soils compared to the previous group. Towards the right of this grouping the herbs *Potentilla*, Ranunculaceae and *Succisa* are located, possibly indicating herb taxa growing on damper acidic soils.

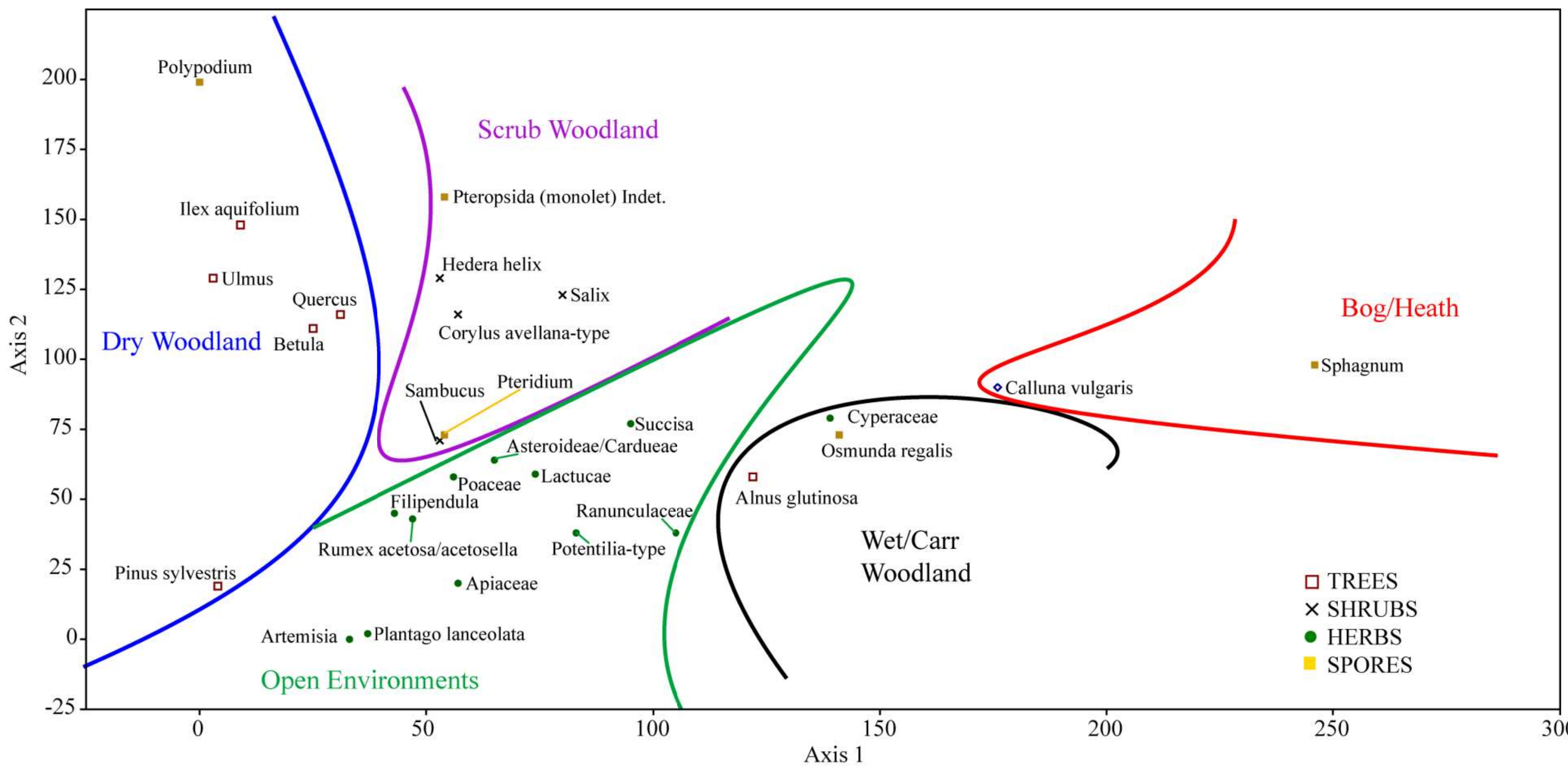

Figure 6.6 Detrended Correspondence Analyses Plot (taxa scores). The lines indicate the recognised groupings (in bold) discussed in the text.

6.2.5. Loss on ignition.

PAZ/ Depth (cm)	PAZ top *PDE*	Main features
ARD12 (40-114)	*1320 cal BC-70 cal AD*	OM values at *c.*94% at beginning of PAZ, decreases briefly to *c.*79% at 72cm. Further increase to *c.*85% between 68cm and 52cm, before decreasing to *c.*65% by the end of the PAZ
ARD11 (114-186)	*1850-1480 cal BC*	OM values fluctuate between 85% and 92% throughout the PAZ, slight decrease to *c.*80% at 148cm
ARD10 (186-218)	*2430-1940 cal BC*	OM values at *c.*90% at beginning of PAZ, decrease to *c.*87% by end of PAZ
ARD9 (218-242)	*2560-2270 cal BC*	OM values at *c.*85% at beginning of PAZ, increases to *c.*92% by end of PAZ
ARD8 (242-274)	*2870-2470 cal BC*	OM values fluctuate between 85% and 89% throughout the PAZ
ARD7 (274-311)	*3250-2730 cal BC*	OM values decrease from *c.*85% at beginning of PAZ to *c.*75% at 296cm, increases again to *c.*82% at 292cm and remains *c.*82% for the rest of PAZ
ARD6 (311-323)	*3650-3220 cal BC*	OM values at *c.*85% at beginning of PAZ, decrease to *c.*79% by end of PAZ
ARD5 (323-337)	*2560-2270 cal BC*	OM values at *c.*87% at beginning of PAZ, decrease to *c.*83% by end of PAZ
ARD4 (337-371)	*3810-3520 cal BC*	OM values at *c.*67% at beginning of PAZ, increase to *c.*80% by 348cm and again to *c.*85% by end of PAZ
ARD3 (371-394)	*3930-3620 cal BC*	OM values at *c.*73% at beginning of PAZ, decrease to *c.*65% by 380cm
ARD2 (394-438)	*4650-3950 cal BC*	OM values increase from *c.*55% to *c.*70% by 420cm and remain between *c.*65% and *c.*70% for the rest of the PAZ
ARD1 (438-512)	*5540-4310 cal BC*	OM is *c.*55% at base of profile, reduction to *c.*40% by 496cm. Remains at *c.*45% until 464cm with a brief increase to *c.*60% at 484cm. Fluctuates between *c.*50% and *c.*55% for the rest of the PAZ

Table 6.7 Summary of Loss on Ignition data from Arderrawinny (ARD).

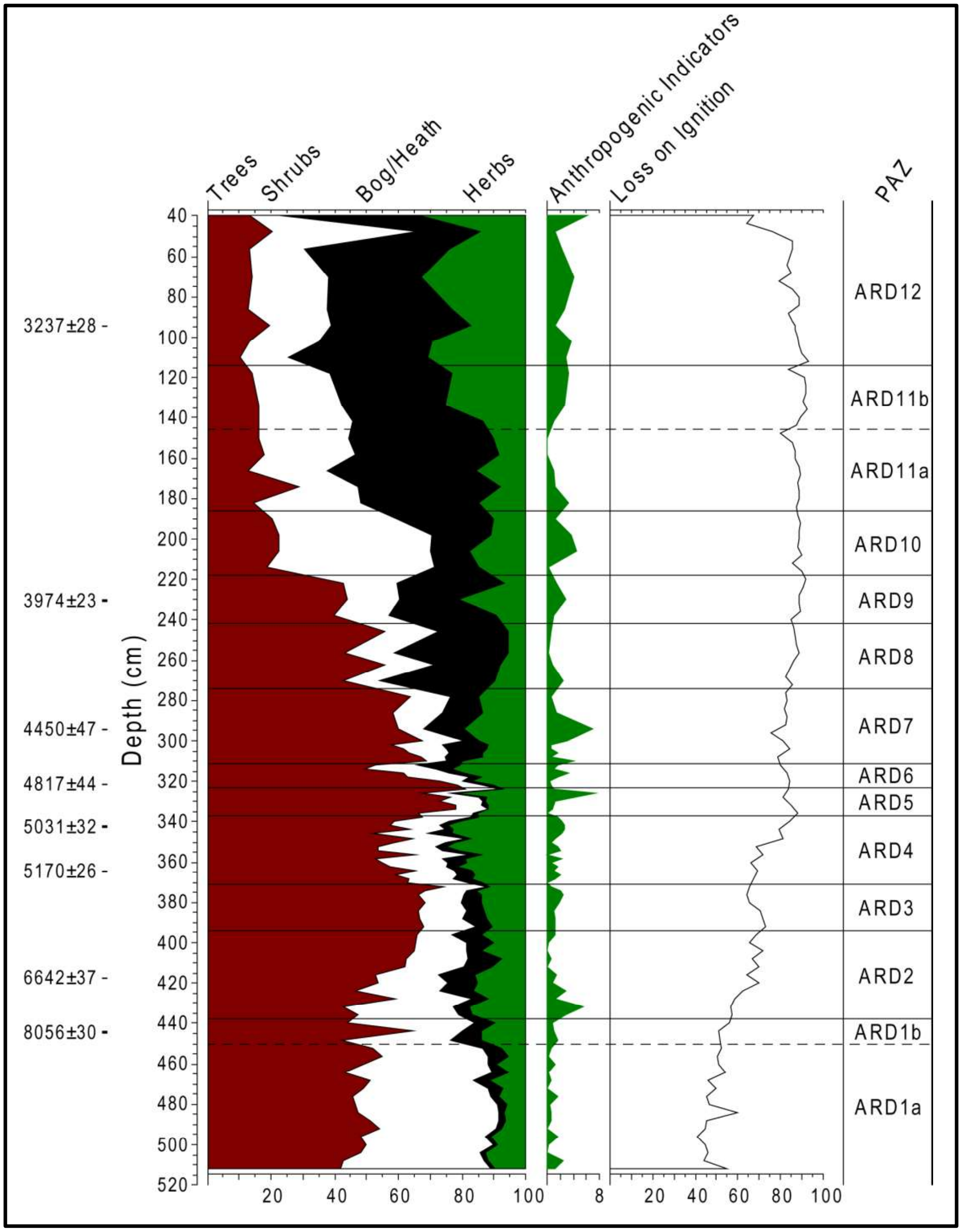

Figure 6.7 Loss on Ignition data from Arderrawinny (ARD)

6.3. Interpretation.

6.3.1. PAZ ARD1 512 – 438cm, *8870 – 7210 cal BC* to *7070 – 6040 cal BC.*

The pollen profile opens at a date of *8870 – 7210 cal BC* with *Corylus* as the dominant taxon with pollen percentage values of *c.*42% total land pollen (TLP). The arboreal taxa are dominated by *Quercus* and *Betula*, with lesser amounts of *Pinus*, and *Ulmus*. The abundance of *Corylus* would indicate that it comprised the major component of the local vegetation, and its high values in addition to the continuous presence of *Salix* and occasional *Sambucus* (elder) may also suggest that the woodland was more scrub-like, possibly growing in stands or thickets close to the sampling site or interspersed within the exposed bedrock to the south and east. The values of *Quercus, Betula*, and to a lesser extent *Ulmus* (cf. Lisitsyna *et al.* 2011) would indicate that they were also present to some degree within the local landscape.

The low values of *Pinus* in this PAZ may suggest that it was not dominant in the landscape and possibly reflected long-distance transport from elsewhere on the peninsula (cf. Pilcher *et al.* 1995; Lageard *et al.* 1999; Lisitsyna *et al.* 2011). Several studies have noted the problematic nature of reconstructing the post-glacial history of *Pinus* based on palynological investigations (Turner 1970; Bennett 1984; Pilcher *et al.* 1995; Mighall *et al.* 2004). *Pinus* is a prolific pollen producer and its pollen is well adapted for long distance dispersal, making it difficult to distinguish between local and regional pollen sources (Pilcher *et al.* 1995; Lageard *et al.* 1999). Indeed, various studies have employed the criterion that pollen percentage values of between 20 – 30% be satisfied to infer the local presence of *Pinus* (Huntley and Birks 1983; Bennett 1984; Gear and Huntley 1991). This would suggest that *Pinus* had become the main components of the local woodland canopy until PAZ ARD2. In contrast Fossitt (1994) and Hall *et al.* (1996) have argued that values of 5% TLP are sufficient to infer a local presence of *Pinus,* while Lageard *et al.* (1999) found that *Pinus* pollen percentages of between 3 – 9% TLP in palynological studies from bogs can reflect a local source of *Pinus.*

The woodland structure in this PAZ is likely to have consisted of scrub woodland (WS1, Fossitt 2000, 55) comprised of stunted *Corylus* and *Salix,* with the tall trees, such as *Quercus* and *Ulmus*, possibly growing in scattered distribution further to the north and east of the sampling site. The scrub woodland may also be comprised of small *Betula* trees, however, the DCA plots this with both *Quercus* and *Ulmus*, which would indicate that it grew as tall trees within the scattered broadleaf woodland. The continuous presence of *Hedera helix* may also suggest this grew as an epiphyte within the broadleaf woodland, however, the DCA indicate it comprised a component of the scrub woodland.

Though woodland scrub dominated, open habitats persisted, at least in the vicinity of the sampling site. This is implied by the values for Poaceae and the sporadic occurrence of light demanding non-arboreal taxa such as *Plantago lanceolata,* Caryophyllaceae, Chenopodiaceae (fat-hen) and *Urtica*. These open environments likely consisted of a mix of tall-herb, wet grassland (GS4, Fossitt 2000, 31-32), indicated by the presence of Ranunculaceae, Asteraceae (Asteroideae/Cardueae) undif. and *Filipendula*, at the edge of the sampling site and dry-humid acid grassland (GS3, Fossitt 2000, 30-31), indicated by the presence of *Rumex acetosa/acetosella*, *Potentilla*-type (cinquefoils) and *Succisa pratensis* (devil's bit scabious), growing on the more mineral-rich or peaty podzol soils to the immediate north of the sampling site. It would therefore appear that the early Holocene woodland around Arderrawinny was not totally closed, although this is probably primarily attributable to the unfavourable edaphic conditions (thin soil) rather than Mesolithic anthropogenic activity.

PAZ ARD1b exhibits a reduced in total land pollen concentration, with fluctuations in pollen percentage and concentration values for *Corylus*, *Quercus* and *Pinus* also evident. This occurs in a single spectrum (444cm, *7080 – 6820 cal BC*) where *Corylus* and to a lesser extent *Quercus* values decrease, and *Pinus* values increase both in pollen percentage and concentration. Values of *Corylus* decline from 31% to 14%, *Quercus* from 35% to 24%, while *Pinus* values increase from 5% to 30% at this level. This reduction in *Corylus* and corresponding increase in *Pinus* is also evidence in the pollen concentration data with *Corylus* concentration declining from *c.*52x10^3 cm^{-3} to *c.*23x10^3 cm^{-3}, while *Pinus* pollen concentration increases from *c.*8x10^3 cm^{-3} to *c.*56x10^3 cm^{-3}. Herbaceous taxa do not appear to respond to this reduction in *Corylus,* with the relative stability of the overall non-arboreal pollen percentage values and limited occurrence of light-demanding ruderal taxa throughout PAZ ARD1b, refuting the possibility of increased open environments or human disturbances as a cause for this reduction in *Corylus*. Declining pollen concentration values, possibly representing reductions in pollen productivity or increased accumulation rates, occurs throughout PAZ ARD1b (between *7080 – 6820 cal BC* and *7080 – 6170 cal BC*). TLP concentration declines from *c.*439x10^3 cm^{-3} at 456cm (*7520 – 6840 cal BC*) to *c.*172x10^3 cm^{-3} at 444cm and remaining low until 436cm (*7060 – 5910 cal BC*).

The loss on ignition data in the PAZ demonstrates minor, yet continuously increasing organic content, possibly suggesting increased soil stability in the immediate vicinity of the sampling basin. The increasing organic context could also signify that the fluctuations exhibited in the percentage values of *Corylus* and *Quercus* was probably unrelated to woodland disturbances within the source area of the sampling site.

6.3.2. PAZ ARD2 438 – 394cm, *7070 – 6040 cal BC* to *5440 – 4310 cal BC.*

In the lower spectrum of PAZ ARD2 there is a small peak in *Corylus* and the earlier trend of low pollen concentration is reversed, with TLP concentration rising from *c.*201x10^3 cm^{-3} at 440cm (*7080 – 6170 cal BC*) to *c.*1615x10^3 cm^{-3} at 436cm suggesting a reversal of the possible lowered rate of pollen production exhibited in PAZ ARD1b. Thereafter, *Pinus* increases considerably throughout the rest of the PAZ, rising from *c.*9% at 436cm to *c.*52% by 396cm (*5480 – 4370 cal BC*). This increase in *Pinus* is at the expense of *Quercus*, *Betula* and *Corylus,* which decline from *c.*20% – 8%, *c.*6% – 2% and *c.*25% – 10% respectively. Arboreal pollen exceeds *c.*75% for the majority of this PAZ, with *Pinus* reaching values of *c.*65% by *5650 – 5350 cal BC. Pinus* probably outcompeted both *Quercus* and *Betula* on the soils to the north and east of the site while *Corylus* was presumably shaded by the expansion of this tall canopy tree.

Alnus increases marginally at the beginning of PAZ ARD2 (*7060 – 5910 cal BC*) to 1.5%, although this presence is not sustained. The low values for *Alnus* is a significant feature of this PAZ and suggests that *Alnus* failed to become established at Arderrawinny and may indicate that the pollen represents long-distance transport and not a local presence of the taxon (cf. Lisitsyna *et al.* 2011; Douda *et al.* 2014). *Alnus* is known to be an abundant pollen producer and to be well dispersed in relation to other arboreal taxa (Andersen 1970; 1974; Huntley and Birks 1983). It is therefore possible that its pollen could be present at a site prior to a local presence and hence low frequencies of *Alnus* pollen may not be a reliable indicator of *Alnus* trees (Bennett and Birks 1990).

Parsons *et al.* (1980), Prentice (1983) and Prentice *et al.* (1987) established a non-linear relationship between the frequency of *Alnus* pollen and the abundance of *Alnus* within the landscape. This was suggested to be as a result of the intermittent occurrence of *Alnus* in the landscape, transport of *Alnus* pollen in streams or the dispersal of *Alnus* pollen over a wider area than other taxa. Several studies have identified thresholds ranging from 0.5% – 8% to establish a regional presence of *Alnus* from pollen diagrams (Lisitsyna *et al.* 2011), with greater agreement for 2% – 3% (Huntley and Birks 1983; Tallantire 1992; Montanari 1996). Lisitsyna *et al.* (2011) suggested a threshold of 2.5%

as an indicator for the regional presence of *Alnus* within approximately 50km of a pollen site, while a threshold of 0.5% has been postulated as an indicator of possible scarce regional occurrence (Lisitsyna *et al.* 2011; Douda *et al.* 2014) and pollen percentage values of 10% or greater are assumed to correspond with the occurrence of an *Alnus*-dominated woodland in the vicinity of the sample site (Bennett and Birks 1990; Montanari 1996; Douda *et al.* 2014).

Therefore, patterns of past *Alnus* growth can be defined as, values of less than 0.5% indicate a regional absence of the taxa, and 0.5% – 2.5% may be the result of long-distance pollen transport but could also represent the presence of relatively small populations in the region. Values of between 2.5% and 10% likely represent *Alnus* growth within the region, while values of 10% or greater are necessary to suggest the local presence of the taxa at the site (Douda *et al.* 2014). It is conceivable that *Alnus* pollen from Arderrawinny represents long-distance travel from a regional source and does not represent a presence locally. The lack of *Alnus* at Arderrawinny may possibly have been due to environmental limitations as despite having no serious climatic limitation in Ireland, it does not grow well on very exposed sites and it is susceptible to salt spray (Horgan *et al.* 2003). The exposed, coastal nature of the sampling site may therefore have restricted the expansion of *Alnus* at Arderrawinny. However, while this may have hindered the later development of *Alnus* at the site, estimates of local sea level change during the mid to late Holocene (Shaw and Carter 1994; Edwards and Brooks 2008) would question how coastal the site was during this PAZ.

Despite the alterations in composition of the principal arboreal taxa, overall vegetation is relatively stable as reflected in the slow rates of palynological change across this PAZ. The expansion of tall canopy trees, which may signify that woodland cover was denser in PAZ ARD2 than in the previous PAZ, does not appear to have restricted the degree of vegetation openness in the sampling site basin. Indicators of open habitats persisted, with Poaceae values remaining constant at *c.*10%. The continuous curves for *Rumex acetosa/acetosella, Filipendula* and Asteraceae (Asteroideae/Cardueae) undif. and the occasional appearance of *Plantago lanceolata* and other grassland taxa would also suggest continued meadow-like openings within the woodland canopy. *Cerealia*-type pollen (cereal) is recorded in PAZ ARD2 (416cm or *5650 – 5350 cal BC*), however, this is unlikely to relate to cereal cultivation (see below). The loss on ignition data for PAZ ARD2 again exhibits increasing organic content throughout, which would indicate that despite the continued evidence for open environments locally, no clear evidence for increased soil instability or woodland reduction is apparent.

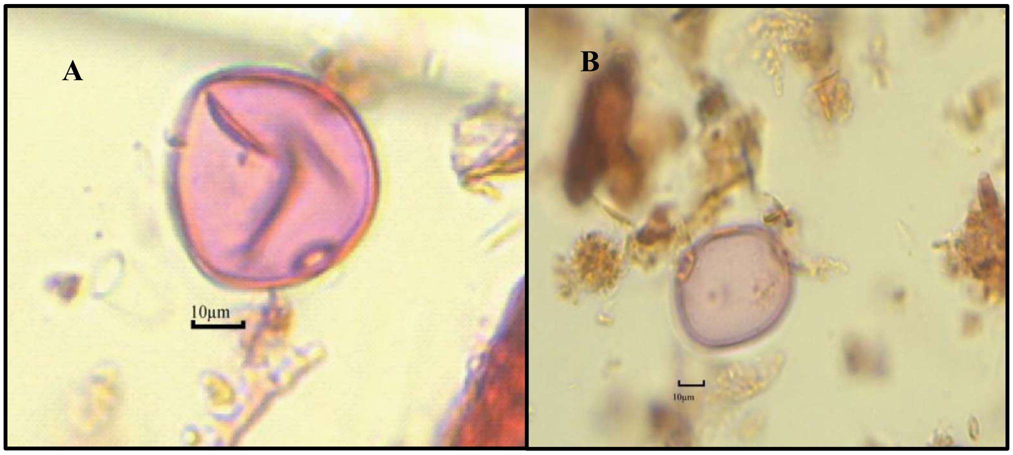

Figure 6.8 Cerealia-type pollen identified at (A) 416cm (43µm) and (B) 230cm (47µm) from Arderrawinny

6.3.3. PAZ ARD3 394 – 371cm, *5440 – 4310 cal BC* to *4650 – 3950 cal BC.*

The local vegetation in this PAZ is characterised by a denser woodland canopy as *Pinus* representation increases to *c*.40% – 50%. The woodland canopy consists of mixed broadleaved/conifer woodland (WD2, Fossitt 2000, 54) with the tall tree component dominated by *Pinus* and *Quercus,* with *Corylus* possibly growing as understorey shrub or as mixed *Corylus*-*Salix* scrub nearer the sampling site. The shade-tolerant tall shrub *Rhamnus cathartica* (common buckthorn) appeared in the local flora for the first time, which may further support the intimation of a denser woodland canopy.

Despite the increased representation of tall canopy trees, continued open environments are evidenced by the stability of the mean ratio of arboreal to non-arboreal pollen across the PAZ. The initiation of a small but continuous curve for *Plantago lanceolata* (range of 0.3% – 1.7%) is exhibited from *5010 – 4000 cal BC*, in contrast with the occasional record from the lower two PAZs. *Plantago lanceolata* does not occur in closed woodlands (Behre 1981; Parnell and Curtis 2012, 335) and so its continuous, if low, representation in the pollen record infers a degree of openness which is seldom recorded in the closed woodland environment of early Holocene contexts in Ireland. Other features of note are the continuous curves for Asteraceae (Asteroideae/Cardueae) undif.

and *Filipendula*, suggesting the sustained presence of areas of wet grassland (GS4, Fossitt 2000, 31-32) near the sampling site.

Despite the rise in taxonomic variation, little clear evidence is provided for increased vegetation openness during this PAZ. Although, the continuous presence of *Plantago lanceolata* and minor decrease in organic content in the loss on ignition data at the top of the PAZ could indicate limited woodland reduction on the mineral soils near the sampling basin.

6.3.4. PAZ ARD4 371 – 337cm, *4650 – 3950 cal BC* to *3930 – 3620 cal BC.*

This PAZ is characterised by the expansion of herbaceous taxa at the expense of the arboreal component of the local vegetation. This increase in NAP values was primarily at the expense of *Pinus*, which declined from *c.*52% at the start of the PAZ to *c.*36% by *4040 – 3860 cal BC*. *Corylus* increased from *c.*13% to *c.*20% by *4040 – 3860 cal BC*, *Sambucus* (elder) (*c.*0.5% – 1%) occurred more frequently and *Quercus* values remained stable throughout. *Ulmus* was present throughout, but at low values, while *Alnus* was recorded more frequently from *5010 – 4000 cal BC*, potentially indicating the limited replacement of *Pinus* by *Alnus* near the lake margin. However, *Alnus* values remained at less than 2% for much of the PAZ which would question whether it replaced *Pinus* locally or within a regional context. Considering the low values for *Alnus* during this PAZ, it is unlikely to represent the establishment of sufficient local populations of the tree (cf. Lisitsyna *et al.* 2011; Douda *et al.* 2014) to account for the considerable reduction in *Pinus* values.

The reduction in *Pinus* is therefore more probable to have resulted from the regression of the woodland canopy and expansion of open environments in the vicinity of the sampling site. This is exhibited with increased percentage values of Poaceae from *c.*10% to *c.*20%, the continued presence of *Plantago lanceolata* and *Filipendula*, both at values of between 0.5% and 2%, and the sporadic, yet frequent occurrences of Apiaceae, Asteraceae (Asteroideae/Cardueae) undif., *Artemisia, Rumex acetosa/acetosella* and *Urtica*. This reduction of arboreal pollen in addition to increased representation of *Plantago lanceolata* and other light-demanding herbaceous taxa points to a decidedly more open woodland environment. *Ilex* is recorded continuously from *4040 – 3860 cal BC*, again suggesting increased opening in the woodland canopy (Godwin 1975; Hirons and Edwards 1986; Molloy and O'Connell 1991). However, the loss on ignition data provides little clear evidence for increase soil instability as the percentage of organic material in the sediment continues to increase throughout the PAZ.

Calluna vulgaris (ling) values increase throughout the PAZ in correlation with a reduction in values of Cyperaceae, while values of *Sphagnum* spp. (bog moss) remain low. This may relate to changes in the hydrology of the sampling site basin and indicate shift to drier conditions on the peatland surface and the development of dry siliceous heath (HH1, Fossitt 2000, 35).

6.3.5. PAZ ARD5 337 – 323cm, *3930 – 3620 cal BC* to *3760 – 3510 cal BC.*

This PAZ sees a sharp fall in *Ulmus* from 2% to 0.3% between 338cm – 336cm and this tree disappears from the palynological record from *3880 – 3560 cal BC* (332cm). Based on the age-depth model employed here the reduction in *Ulmus* from 2% to 0.3% at the base of the PAZ is dated from *3930 – 3640 cal BC.* This reduction in *Ulmus* values is not initially accompanied by an increase in NAP values but is concomitant with an overall increase in arboreal pollen both in percentage and concentration values. NAP fall drastically from *c.*21% to *c.*11% in the same spectra as the decline in *Ulmus*, which could be said to strongly refute any suggestion of an anthropogenic cause for this reduction. The reduction in NAP values primarily relates to a fall in Poaceae values from 12% at *3930 – 3640 cal BC* to 7% by *3880 – 3560 cal BC*, indicating increased woodland cover. The continued presence of *Plantago lanceolata* and *Filipendula* would however suggest that limited open environments remained but other herbaceous taxa do not appear to respond to the reduction in *Ulmus,* which could suggest little, if any, clear signal for anthropogenic activity at Arderrawinny at this time. Evidence supporting this lack of a clear signal for anthropogenic activity is provided by the very minor reduction in organic material in the sediment across the PAZ.

The ratio of trees to shrubs to herbaceous taxa (excluding bog/heath taxa) increases from 68:15:15% to 78:8:11% between 338cm (*3940 – 3680 cal BC)* and 332cm (*3880 – 3560 cal BC*) demonstrates increased woodland cover in respect to the previous PAZ. *Betula* values rise from *c.*3% to *c.*8% immediately after the reduction in *Ulmus*, while *Pinus* in particular shows a marked increase, rising from 47% to 64%, while both *Corylus* and *Quercus* decrease from 15% to 10% and 14% to 6%, respectively over the same spectra. This would indicate that the expansion of *Pinus* exhibited at Arderrawinny occurred at the expense of other arboreal taxa and may also have reduced the levels of open habitats, although not completely, near the sampling site basin

6.3.6. PAZ ARD6 323 – 311 cm, *3760 – 3510 cal BC* to *3650 – 3220 cal BC.*

At Arderrawinny it is not until the top of PAZ ARD5 and into PAZ ARD6 that NAP values begin to increase, rising from 9% at *3720 – 3510 cal BC* to 16% by *3700 – 3510 cal BC*, concomitant with a reduction in arboreal pollen, especially *Pinus.* In a reversal from the previous PAZ the ratio of trees to shrubs to herbaceous (excluding bog/heath) taxa decreases from 78:8:10% to 61:15:20% over the same spectra. This reduction is solely exhibited in values of *Pinus* which decrease from 63% to 42% between *3720 – 3510 cal BC* and *3700 – 3510*, while both *Corylus* and *Quercus* increase from 6% to 13% and 6% to 9% respectively.

The increase in Poaceae to *c.*16% corresponds with the occurrence of *Plantago lanceolata, Rumex acetosa/acetosella,* Ranunculaceae and Asteraceae and may indicate the expansion of meadow-like environments (GS2, Fossitt 2000, 30) near the sampling site basin. This could possibly indicate the presence of Neolithic agricultural activity in the area. However, a caveat must be placed on this interpretation. While the expansion in Poaceae is accompanied by ruderal taxa associated with anthropogenic activity (*Plantago lanceolata, Rumex acetosa/acetosella,* Ranunculaceae, and Asteraceae), these taxa are also present throughout the earlier PAZs of the profile, while the loss on ignition data also provide little evidence for increased soil instability, possibly due to anthropogenic activity, at this time. This would infer, as has been suggested above, that the landscape near the sampling site was rather open from the early Holocene resulting in greater difficulties in determining phases of woodland disturbance in the Early Neolithic. (This will be discussed in more detail below).

6.3.7. PAZ ARD7 311 – 274cm, *3650 – 3220 cal BC* to *3250 – 2730 cal BC.*

This phase of decreased woodlands ends from *3640 – 3200 cal BC* where total tree pollen increases from 53% to 69%, however, this is primarily at the expense of shrubs which decrease from 13% to 6%, while herbaceous pollen remains relatively stable until the following spectrum. This increase in arboreal pollen relates to increased values of *Pinus* which rises from 38% to 55%, while *Quercus* increase incrementally until mid-way through the PAZ before declining to *c.*2% at *3540 – 3070 cal BC.* In contrast *Betula* decreases from 6% to 2% and *Corylus* falls from 12% to 6% at 310cm (*3640 – 3200 cal BC*). This would indicate an overall expansion of tall trees possibly within the wider landscape of Arderrawinny, with both *Pinus* and *Quercus* increasing from the start of the PAZ before *Pinus* expands further at the expense of *Quercus,* reaching values of *c.*60% by *3280 – 2780 cal BC.*

Further supporting evidence for this increase of tall trees within the woodland canopy is exhibited from *3540 – 3070 cal BC* when the continuous curve for *Plantago lanceolata*, present from PAZ ARD3 ends. NAP values decline, from *c.*19% at *3640 – 3200 cal BC* (310cm) to *c.*12% at *3540 – 3070 cal BC* (302cm), although *Plantago lanceolata, Rumex acetosa/acetosella,* Ranunculaceae, and Asteraceae are again present intermittently throughout, suggesting that despite woodland regeneration, limited open habitats persisted close to the sampling site, possibly on the thinner soils interspersed with the bedrock outcrop to the south and west.

Values of Cyperaceae increase as the PAZ progresses and with the presence of *Filipendula,* Lamiaceae (mint), *Digitalis purpurea* and *Potentilla*-type, in addition to the presence of *Vaccinium (cf.) oxycoccos* (bog cranberry) macrofossils in the sediment indicate wetter surface conditions on the mire surface (Parnell and Curtis 2012, 310).

6.3.8. PAZ ARD8 274 – 242cm, *3250 – 2730 cal BC* to *2870 – 2470 cal BC.*

This PAZ exhibits increased levels of Cyperaceae from *c.*8% to *c.*35%, a sharp rise in *Osmunda regalis* from *c.*7% to *c.*37%, and the beginning of a continuous curve for *Sphagnum* spp. possibly indicating changing hydrological conditions and further increased wetness on the mire surface. *Pinus* values fluctuate throughout the PAZ, while NAP values are further reduced and reach their lowest levels for the entire profile, *c.*5% by *3060 – 2550 cal BC* (256cm). Poaceae values fall from *c.*14% – 5% between *3250 – 2730 cal BC* and *3060 – 2550 cal BC*, and the overall values for anthropogenic indicators are reduced to minimal levels. However, this relates to an increase in Cyperaceae and not an expansion of the woodland canopy as arboreal pollen also declines from 64 to 43%, while values for shrubs remain relative stable.

6.3.9. PAZ ARD9 242 – 218cm, *2870 – 2470 cal BC* to *2560 – 2270 cal BC.*

Potential ecological changes in the local environment are exhibited from PAZ ARD9, with decreased arboreal pollen values demonstrating further opening of the woodland canopy. Arboreal values decline from *c.*55% at the top of the previous PAZ to *c.*40% by the start of PAZ ARD9. This is most apparent in values of *Pinus* which decline from *c.*47% at *2870 – 2470 cal BC* to *c.*25% by *2570 – 2460 cal BC*, while values for *Quercus, Corylus* and *Betula* remain relatively stable. The reduction in *Pinus* is concomitant with an initial rise in Cyperaceae from *c.*20% to *c.*27% and Poaceae from *c.*5% to *c.*17% between *2870 – 2470 cal BC* and *2570 – 2460 cal BC.* This, in addition to the occurrence of wet-loving taxa, *Filipendula, Potentilla*-type, *Digitalis* and Lamiaceae, possibly indicates local hydrological changes which could be the cause for the reductions in *Pinus.*

The increased values for Poaceae, Cyperaceae and the presence of wetland herbs such as *Filipendula*, infer this opening of the landscape resulted from the expansion of wet grassland (GS4, Fossitt 2000, 31-32) or mire growth locally, indicated by the increases in *Sphagnum* spp., throughout the PAZ. This may infer that *Pinus* was growing on the poorer soils near the sampling site while both *Quercus* and *Betula* were on the better mineral soils and were thus not affected by the changing hydrological conditions and the expansion of wet grassland.

The presence of *Cerealia*-type pollen in PAZ ARD9 (*2400 – 1790 cal BC*) may suggest arable activity in the vicinity. While *Cerealia*-type pollen is well known to be under-represented in pollen records due to poor dispersal (Behre 1981; Hall *et al.* 1993), one pollen grain, without the accompanying ruderal taxa usually indicative of arable activity (Behre 1986), may be insufficient evidence for arable farming.

6.3.10. PAZ ARD10 218 – 186cm, *2560 – 2270 cal BC* to *2430 – 1940 cal BC.*

This PAZ is characterised by the further reductions in *Pinus* levels to *c.*5% by *2560 – 2240 cal BC*, this is concomitant with a dramatic increase in *Corylus* to reach peak levels of *c.*50% by *2550 – 2190 cal BC.* The reduction of *Pinus* is not accompanied by clear evidence for increased woodland disturbances, with only marginal expansion of Poaceae and the occasional presence of *Plantago lanceolata* and other anthropogenic indicators.

The loss in ignition data also exhibits little evidence for soil instability as the values of organic material in the sediment remains relatively stable throughout the PAZ. It would therefore appear the reduction in *Pinus* across this PAZ represents the replacement of the tree in the local landscape with *Corylus* scrub.

Representation of *Calluna vulgaris* increases, while Cyperaceae values decline sharply at the beginning of this PAZ, decreasing from 28% to 7% between *2560 – 2270 cal BC* and *2560 – 2240 cal BC.* This in addition to reductions in values of *Sphagnum* spp. may relate to changes in the hydrology of the sampling site basin and indicate the development of dry siliceous heath (HH1, Fossitt 2000, 35).

6.3.11. PAZ ARD11 186 – 114cm, *2430 – 1940 cal BC* to *1850 – 1480 cal BC.*

The peak values of *Corylus*, exhibited in the previous PAZ are not sustained and begin a continuous decline from PAZ ARD11, with percentage values falling from 39% at the start of the PAZ to *c.*17% by *2350 – 1840 cal BC.* Herbaceous taxa do not appear to respond to the reduction in *Corylus* which would suggest little, if any, clear signal for increased grassland environments at Arderrawinny at this time. Indeed, this reduction of *Corylus* corresponds with increased *Calluna vulgaris* values in PAZ ARD11a. The reduction in *Corylus* therefore probably relates to the expansion of dry siliceous heath (HH1, Fossitt 2000, 35) in the sampling site basin.

PAZ ARD11b is characterised by the continued reduction in *Corylus* and lower *Calluna vulgaris* values, with Cyperaceae and Poaceae becoming the dominant taxa. This increase in Cyperaceae, in addition to a peak in *Sphagnum* spp. values again suggest a shift in hydrological conditions in this PAZ. The increase in both Cyperaceae and *Sphagnum* spp. would suggest wetter surface conditions in the sampling site basin and may account for the reduction in *Calluna vulgaris*.

6.3.12. PAZ ARD12 144 – 40cm, *1850 – 1480 cal BC* to *1320 cal BC – 70 cal AD.*

Arboreal taxa fall to their lowest values of the entire profile, *c.*10%, at the start of PAZ ARD12, while values of *Corylus* also continue to decrease throughout. *Alnus* representation becomes more pronounced, reaching values of *c.*7% by the end of the PAZ, which would indicate that the taxa had become a minor component of the local vegetation

(Lisitsyna *et al.* 2011; Douda *et al.* 2014). The presence of *Alnus* within the local landscape, in addition to the considerable increase in *Salix* may indicate the development of patches of wet *Alnus-Salix* carr woodland, (WN6, Fossitt 2000, 52-53) at the edge of the sampling site, although the DCA would suggest that *Salix* plots with the scrub woodland taxa. The continued strong presence of Cyperaceae, in addition to *Filipendula, Galium* (bedstraw) and Ranunculaceae would support this suggestion as these are often associated which such habitats (Fossitt 2000, 53).

Increased values of Poaceae and the reinstatement of a continuous curve for *Plantago lanceolata* from *1610 – 1430 cal BC* would infer increased grassland habitats in the local landscape, possibly on the drier mineral soils to the north of the sampling site. Herbaceous taxa more indicative of grazed swards such as *Trifolium* are also recorded at the top of the PAZ and with the greater representation of Brassicaceae, *Artemisia, Urtica,* Asteraceae (Asteroideae/Cardueae) undif. and Asteraceae (Lactucae) undif. would suggest the presence meadow-like grasslands (GS2, Fossitt 2000, 30). The decreased organic content exhibited in the loss on ignition data may indicate increased soil instability near the sampling basin and with the renewed presence of ruderal taxa indicative of anthropogenic activity from *1610 – 1430 cal BC* could possible suggest that Bronze Age farming was being undertaken in the vicinity of the sampling site.

6.4. Discussion

The following section discusses the vegetational history of the site as reconstructed through the pollen and loss on ignition analyses. It also focuses on evidence for human agency discovered within these records together with the evidence from regional pollen studies and archaeological sites. The discussion takes place chronologically covering those archaeological periods represented in the pollen profile.

6.4.1. History of woodland development and natural vegetation dynamics

Early Holocene

The pollen record from Arderrawinny presented here spanned much of the early and middle Holocene, from *8870 – 7210 cal BC* to *1320 cal BC – 70 cal AD,* and provided insights into vegetational responses to ecological and anthropogenic conditions from the

Early Mesolithic to the beginnings of the Late Bronze Age/Iron Age period. The early Holocene landscape at Arderrawinny was dominated by a woodland scrub of hazel and willow, while tall canopy trees oak, birch and elm were also present within the landscape. However, the local edaphic conditions and the ridges of exposed bedrock to the west and south of the sampling site were likely to have restricted the formation of a closed deciduous canopy at Arderrawinny. Comparable with Lough Cullin, the low values of pine in the early Holocene levels at Arderrawinny would also indicate that the tree had yet to become established in the sampling basin. Pine does not appear to have been present in south-west Ireland until after 9500 cal BP (Mitchell 2006, 253; 2008, 74), becoming abundant at Arderrawinny from *7080 – 6820 cal BC*, prior to 6030 – 5750 cal BC (7030±70, *GrN-21475*) at Mount Gabriel (Mighall *et al.* 2008, 621) and from 7050 – 6650 (7930±70, *GrN-22077*) further west at Sheheree Bog, in the Killarney valley (Mitchell and Cooney 2004, 484).

Though woodland dominated, open habitats persisted, as evidence by the high grass values and the presence for light demanding non-arboreal taxa such as ribwort plantain. The continuous presence of such non-arboreal taxa in this period was unusual for Irish pollen profiles, although a similar NAP record is recorded at Caherkine Lough, County Clare (O'Connell *et al.* 2001) and Lough Mór on Inis Oírr (Molloy and O’Connell 2004), and was probably primarily attributable to the unfavourable edaphic conditions rather than Mesolithic anthropogenic activity.

8.2 kyr event

A potential response to changing thermal conditions was noted at Arderrawinny, although this appears to have occurred several centuries earlier than at Lough Cullin, at *7080 – 6820 cal BC.* These fluctuations in hazel, oak and pine values at Arderrawinny were similar to a fluctuations of the same taxa at Lough Cullin, however, this ‘event’ appears to lie outside the accepted date range for climate deterioration around the time of the 8.2kyr BP event (Rohling and Pälike 2005). Rohling and Pälike (2005) suggest that the sharp 8.2kyr BP event, where present, occurred within a broader anomaly with an interval of 8.4 – 7.9kyr BP for the timing and duration of this broad climate deterioration. Studies of sediment cores from the eastern Norwegian Sea (Risebrobakken *et al.* 2003) also demonstrated that the typical sharp signature of the 8.2kyr BP was again within a broader climatic anomaly occurring between 8.5 and 7.9kyr BP. However, at Arderrawinny the fluctuation in hazel, oak and pine values appears to have occurred prior to this longer period of climatic deterioration, while a similar fluctuation in hazel values is recorded at Ballinloghig Lake from *c.*9,700 BP (Barnosky 1988, 33) and also at Lough Adoon Valley (Dodson 1990), which could possible indicate an earlier phase of climatic or environmental deterioration in the south-west.

Pre-'Elm Decline'

Following this pine increases considerable to become the dominant woodland taxon, at the expense of oak, birch and hazel. The expansion of alder, which characterises the beginning of the Atlantic period in north-west Europe was unusually absent at Arderrawinny. While alder is deemed to have had become established within the woodland canopy across much of Ireland between 7000 and 6000 BP (Birks 1989), much research from the southwest would suggest a later date for the alder expansion in the region (Mitchell 1989), arriving at Ballinloghig Lough around 5250 BP (Barnosky 1988), Cashelkeelty by 5000 BP (Lynch 1981) and even later on Valentia Island (Mitchell 1989). At Cadogan's Bog (Mighall *et al.* 2004) and Mount Gabriel 4 (Mighall *et al.* 2008), on the Mizen peninsula, alder appeared only sporadically until after 4340 – 4050 cal BC (5390±50, *SRR-655*) and 5000 – 4740 cal BC (5982±44, *Wk-15142*) respectively. This pattern was repeated at Mount Gabriel 1 (Mighall and Lageard 1999) where alder did not appear in values >1% until shortly before 2570 – 2140 cal BC (3870±70, *GrN-21474*). At Arderrawinny, alder appeared infrequently and in low values until *5010 – 4000 cal BC*, before becoming more frequent from *2430 – 1940 cal BC.*

The general absence of spatial coherence of the alder expansion within Britain and Ireland appears to be very specific in comparison to the generally observed 'stepping stone' nature of expansion for other arboreal taxa (Bennett and Birks 1990). This likely suggests that the delayed alder expansion evidenced in certain regions resulted from environmental constraints rather than the effect of slow colonisation and may account for the unusual absence of alder at Arderrawinny at this time, especially considering the sampling site location.

The expansion and continuous presence of ribwort plantain recorded at Arderawinny prior to the mid-Holocene 'Elm Decline' (from *5010 – 4000 cal BC*) is unusual in Irish pollen diagrams. However, a number of pollen diagrams, notably Clowanstown (Gearey *et al.* 2010) recorded a slender ribwort plantain curve from 4450 – 4330 cal BC (5510±20, *NZA-34453*), while at Lough Mór (Molloy and O'Connell 2004) a more pronounced presence is exhibited from a similar timeframe. Ribwort plantain does not occur in closed woodlands (Behre 1981; Parnell and Curtis 2012, 335) and so its continuous, if low, representation in the pollen record inferred a degree of openness that was unexpected in the closed woodland environment of pre-'Elm Decline' contexts in Ireland.

The factors which led to this early woodland openness are difficult to ascertain, Neolithic agricultural activity was unlikely to have contributed to this as Neolithic *Landnam* phases in Irish palynological records are customarily identified in post-'Elm Decline' contexts (O'Connell and Molloy 2001) and recent studies have placed the commencement of Neolithic practices in Ireland to the mid-38th century cal BC (Cooney *et al.* 2011; McLaughlin *et al.* 2016). It is therefore unlikely that a pre-'Elm Decline' *Landnam* occurred at Arderrawinny, particularly one which had such a prolonged duration of *610 – 1760* years. Given the nature of the local edaphic environment, the degree and duration of woodland openness at Arderrawinny was probably influenced by the terrestrial environment of the area rather than anthropogenic activity.

'Elm Decline'

This sharp fall elm values from *3890 – 3700 cal BC* likely represents the mid-Holocene 'Elm Decline' at Arderrawinny. Although significant decreases in elm were exhibited in certain diagrams from elsewhere (e.g. Pilcher and Smith 1979; O'Connell 1980; Hirons and Edwards 1986; see also O'Connell and Molloy 2001; Parker *et al.* 2002; Whitehouse *et al.* 2014), low elm values characterise pollen diagrams from south-west Ireland, often resulting in difficulties identifying the mid-Holocene 'Elm Decline' said to be common across Britain and Ireland between 5500 and 4800 BP. This is particularly apparent on the Mizen peninsula, where elm pollen rarely occurred at values of greater than 3% at Arderrawinny, 1% at Cadogan's Bog (Mighall *et al.* 2004) and similarly at Mount Gabriel 1 and 4 (Mighall and Lageard 1999; Mighall *et al.* 2008) suggesting that elm was a minor woodland component on the Mizen peninsula.

The mid-Holocene decline in elm is the major palynological event associated with the onset of Neolithic activity in Ireland and is often viewed as concomitant with the beginnings of early agriculture. Several hypotheses have been postulated for this event including one or a combination of, climate change, soil deterioration, anthropogenic activity and pathogenic attack (Girling and Greig 1985; Girling 1988; Peglar and Birks 1993; Parker *et al.* 2002) but the available pollen dataset does not permit the definitive differentiation of the effects of human impact or disease. The 'Elm Decline' at Arderrawinny was not accompanied by evidence for open habitat expansion or human activity, as NAP values decline in the immediate aftermath of the decline in elm. This contrasts with other examples elsewhere in Ireland, Lough Gur (Almgren 1989; Ahlberg *et al.* 2001), An Loch Mór (Molloy and O'Connell 2004) and the Bog of Cullen (Molloy 2008) where the decline in elm was quickly followed by increased openings in the woodland canopy.

In south-west Ireland, the site at Mount Gabriel (MG1) exhibited a reduction in elm pollen from *c.*5050 BP, based on the age/depth model employed by Mighall and Lageard (1999). Ruderal taxa associated with agricultural activity, such as ribwort plantain, fat-hen, mugwort and daisies, were recorded in association with the reduction in elm. This was followed by a permanent fall in pine and a temporary decline in oak and may reflect Neolithic woodland disturbance. A decline in elm was also identified at Ballyally Lough and Lough Ine (Buzer 1980), further east along the Cork coast. While lacking radiocarbon dates, Buzer (1980) tentatively hypothesised that the reduction in elm at both sites represented the mid-Holocene 'Elm Decline'. Buzer (1980) further argues for possible Neolithic human activity at Ballyally Lough, where an increase in grass and the occurrence of bracken and ribwort plantain coincides with a reduction in arboreal pollen.

The pollen record from County Cork suggest that human impact on vegetation in the Early Neolithic was minimal. This evidence for low levels of human impact is supported by pollen studies from elsewhere in south-west Ireland. At Ballinloghig lake (Barnosky 1988) on the Dingle peninsula, despite incidental occurrences of ribwort plantain between 6700 and 4000 BP, signs of anthropogenic impact on vegetation remained low until the Later Neolithic and Early Bronze Age. In contrast, potential Early Neolithic human activity has been suggested at Cashelkeelty, County Kerry (Lynch 1981) where disturbances in the pine dominated woodlands at 4950 – 4460 cal BC (5845±100, *UB-2413*) and between 5620 and 5020 BP was suggested to represent human activity in the vicinity. Neolithic human activity was also inferred on Valentia Island, at Reenarea Rise, Brendan Rock Knoll and Bray West Embayment (Coxon 1985; Mitchell 1989), while Jessen (1949) also interpreted a sharp fall in pine and oak with a subsequent rise in grass at Emlaghlea Bog County Kerry as an episode of Neolithic woodland disturbance.

Post-'Elm Decline'

The 'Elm Decline' with its temporal association with evidence for anthropogenic activity is used in palynological investigations as a chronological proxy for the start of the Neolithic but recent studies by Whitehouse *et al.* (2014) have proposed that this chronological marker may not be as synchronous as previously suggested. The temporal association between the 'Elm Decline' and Early Neolithic human disturbance is often separated in Irish pollen records (O'Connell and Molloy 2001), which may be an effect of increased stimulation of arboreal pollen production resulting from increased light when the woodland canopy is opened (cf. Aaby 1986). In this situation, reductions in overall arboreal populations may not necessarily be represented in the pollen record. This may account for the often-noted time lapse between the 'Elm Decline' and *Landnam* phase identified at numerous sites (e.g. Brown *et al.* 2005; Ghilardi and O'Connell 2013) and identified here, where the decline in elm values was followed by increased overall arboreal values and reductions in the non-arboreal component.

Indeed, at Arderrawinny it was not until *3720 – 3510 cal BC* that non-arboreal values increased, showing a gap of *30 – 350* years between the classic 'Elm Decline' and increase evidence for openings in the woodland canopy. This involved further opening-up of the already relatively open landscape and elevated values for hazel which occur at this time may also be a result of increase pollen production in response to the reduction in the tall tree component of the canopy (cf. Aaby 1986). This is generally indicative of increased open habitats and biodiversity with the possibility of rare non-arboreal taxa being identified due to the altered ratio between arboreal and non-arboreal pollen. However, it must be borne in mind that the increased pollen percentage values of non-arboreal pollen exhibited at his time is similar to those identified in early pre-'Elm Decline' levels, rendering it unclear if this resulted from Neolithic anthropogenic woodland disturbance or local edaphic conditions.

Increased woodland cover, especially pine and oak, was again exhibited from *3540 – 3070 cal BC*, and the continuous presence of ribwort plantain ends. This pattern of decreased open environments continued uninterrupted until *3060 – 2550 cal BC*, by which time grass and other potential anthropogenic indicators have reached their lowest levels of the entire profile. A similar pattern of reduced open environments is noted at Lough Cullin (**Chapter 5**) and elsewhere across the island during the Middle Neolithic (e.g. Pilcher and Smith; O'Connell 1980; Almgren 1989; Molloy and O'Connell 1991; 1995a; 2004; Caseldine and Hatton 1996; Hirons and Edwards 1986; O'Connell and Molloy 2001; Ahlberg *et al.* 2001; Molloy 2008; Ghilardi and O'Connell 2013; Molloy *et al.* 2014).

The reduction in pine at Arderrawinny from *2870 – 2470 cal BC* likely marked the beginnings of the 'Pine Decline' in the region. The decline of pine, beginning around 4000 BP, has been well documented across much of Ireland, northern Scotland and England (e.g. Bennett 1984; Bridge *et al.* 1990; Gear and Huntley 1991; Pilcher *et al.* 1995; Lageard *et al.* 1999; Mighall *et al.* 2004). In south-west Ireland this decline is noted in diagrams from around 4000 BP, though the rate is variable (Monk 1993). Values began to fall at *c.*5275 BP at Ballinloghig Lough (Barnosky 1988) and around 4500 BP at Lough Camclaun (Dodson 1990), while Mighall *et al.* (2004) identified the 'Pine Decline' at 2890 – 2580 cal BC (4160±50, *SRR-655*) at Cadogan's Bog the Mizen peninsula. Although relatively high pine values are known to exist elsewhere in the region after this 4000 BP date, surviving on Valentia Island until around 3000 BP (Mitchell 1989) and until *c.*1500 BP at Derrycunihy, near Killarney (Mitchell 1988). If the age-depth model employed here is correct this would suggest a similar date for the 'Pine Decline' at Arderrawinny as exhibited elsewhere on the Mizen peninsula.

Numerous competing hypotheses have been proposed for the cause of this demise in pine including anthropogenic activity (Dodson 1990), the spread of blanket peat and changing hydrological conditions (Bradshaw and Browne 1987). Prehistoric human activity is often proposed as having contributed to the decline in pine during the mid-Holocene (Tipping *et al.* 2008). While this may be true for some local areas (Dodson 1990), palynological evidence is lacking on a regional scale (Dwyer and Mitchell 1997; Mighall *et al.* 2004). Alternatively, Blackford *et al.* (1992) suggested a possible link between the deposition of Icelandic Helka-4 and an abrupt decline in pine in northern Scotland. However, Hall *et al.* (1994; 1996) and Dwyer and Mitchell (1997) have shown that the deposition of tephra and the decline in pine are asynchronous in Ireland. A combination of climate change, in particular increased precipitation, and the resulting increased surface wetness appears to be the most favoured causal factor (Birks 1975; Bennett 1984; McNally and Doyle 1984; Bradshaw and Browne 1987; Bridge *et al.* 1990; Anderson 1995; Lageard *et al.* 1999).

The recent study by Mighall *et al.* (2004) from Cadogan's Bog on the Mizen Peninsula suggested the reduction in pine occurred concomitant with a short-lived increase in wet-loving mire taxa. Mighall *et al.* (2004) suggest increased surface wetness, possibly resulting from increased precipitation, created conditions unsuitable for pine growth. The study also identified a reduction in concentrations of phosphorus, potassium, magnesium, calcium, sodium, iron and zinc in association with this period of increased surface wetness. This would indicate that the mid-Holocene 'Pine Decline' at Cadogan's Bog was potentially caused by soil mineral deficiency and increased surface wetness, possible due to climate change in the form of increased precipitation. The pollen percentage diagram from Arderrawinny would seem to infer a similar casual factor, with increased evidence for wetland taxa when pine values begin to decline.

In the Late Neolithic to Early Bronze Age a potential shift in hydrological conditions was evidenced in the expansion of wet-loving herbaceous taxa. This expansion of wet-loving taxa is also indicated across the wider south-west region at this time (Barnosky 1988; Dodson 1990; Mighall and Lageard 1999), while Monk (1993) notes that the spread of blanket peat commenced across the region at this time. Hazel representation increased considerably, which would intimate a return to scrub woodland in the extra-local landscape of the sampling basin, while increased heather may indicate the development of dry siliceous heath. Increased representation of heather was also recorded at Mount Gabriel (Mighall *et al.* 2008) and Cadogan's Bog (Mighall and Lageard 1999), further north on the Mizen peninsula, possibly indicating the acidification of soil and the growth and expansion of blanket peat in the region.

Heather representation declines as the profile progresses concomitant with increased representation of grass, sedge, bog moss and tormentils. This may indicate that the hydrological conditions on the mire surface had become too wet for heather growth, or the increased wetland herbaceous taxa indicated an expansion of wet grassland in the immediate environs of the lake edge. Alder is likely to have become a component of the local landscape by *2430 – 1940 cal BC*, similar to at Cadogan's Bog (Mighall and Lageard

1999) and with increased willow representation may indicate the development of patches of alder-willow carr woodland at the edge of the lake.

Herbaceous taxa also increased during the Late Bronze Age and with the continuous presence for ribwort plantain from *1610 – 1430 cal BC*, clover and other ruderal taxa may indicate the presence grassland habitats or grazed swards, which may suggest the presence of Bronze Age farming communities at Arderrawinny.

6.4.2. Human impact, tomb construction and early farming

The Mesolithic period is represented by the basal four zones of the pollen profile from Arderrawinny, which suggest that the local landscape was relatively open during this period. The cause of this openness is debateable in the absence of archaeological evidence for a Mesolithic presence in the region, although a Late Mesolithic presence was suggested from the palaeoenvironmental records at Mount Gabriel further north on the Mizen peninsula (Mighall and Lageard 1999; Mighall *et al.* 2008). Possible woodland disturbances were inferred at *c.*8365 BP and again at *c.*7715 BP (Mighall *et al.* 2008, 625), where reductions in the values of arboreal pollen was recorded simultaneous with an increase in microscopic charcoal concentrations. An increase in microscopic charcoal at *c.*8365 BP was accompanied by a decrease in oak, pine, and hazel, while non-pollen palynomorphs, *Gelasinospora* and *Sordariaceae* (T55A/B) (*ibid.*, 626), often associated with burning, dung or dead wood (Innes and Blackford 2003), were also recorded. Increased values in bracken, grass, buttercups and clover are also exhibited during this phase suggesting opening of the woodland canopy. High microscopic charcoal values suggested fire close to the site, however, the absence of charcoal fragments in the macro-fossil record at this level suggests that there has not been burning of the local carr. Further increased values of macro-charcoal were also recorded from *c.*7715 BP, suggesting burning of the local woodland and increased open environments at this time.

The use of 'fire ecology' (Woodman 2015, 261) for woodland manipulation during the Mesolithic has also been suggested around the Antrim Plateau (Smith 1970), at Newlands Cross, County Dublin (Preece *et al.* 1986) and at Lough Mullaghlahan and Lough Nabraddan, County Donegal (Fossitt 1994), where increased micro-charcoal representation was exhibited concomitant with vegetation change. However, issues relating to taphonomy, source area and the accurate interpretation of sedimentary micro-charcoal records for the reconstruction of fire history still persist (Mooney and Tinner 2011). Innes *et al.* (2004), examining the mid-Holocene microscopic charcoal record from two near-duplicate peat profiles located close together in the North York Moors, noted that while the major trends of the two charcoal curves were found to correspond, differences were exhibited between the pollen profiles. Additionally, Edwards and Whittington (2000) attempting to quantify the source area of microscopic charcoal in three littoral and one central location in Black Loch, Scotland, noted a considerable variation in the influx of charcoal from that of pollen, suggesting differences in taphonomic process between the proxies. Edwards & Whittington (2000, 79) concluded that 'the charcoal records from each of the profiles would have yielded a similar interpretation of fire history' but that differences in influx values 'would discourage' (*ibid.*, 84) attempts to calculate fire frequency, while the differing values for charcoal concentration and influx could infer varying interpretations as to the degree of burning or the fires distance from the loch (*ibid.*, 79).

Attempting to distinguish anthropogenic burning from natural wildfires may therefore be highly problematic. The use of microscopic charcoal within pollen sequences to determine anthropogenic fire 'events' represents a complex interplay of climatic, taphonomy and possibly human activity (Edwards and Whittington 2000) with 'any distinction realistically based upon circumstantial evidence' (Warren *et al.* 2014, 639). As noted by Edwards and Whittington (2000, 79), while increased charcoal frequency provides an indication that burning of combustible materials has taken place, it does not of necessarily indicate the burning of standing vegetation, either from natural causes or through human activity, and the charcoal could also derive from camp fires or other domestic fires (Edwards 1989).

Despite this uncertainty about the use of micro-charcoal to determine anthropogenic activity, clearings in the natural woodland certainly existed (e.g. Fossitt 1994; Huang 2002) and, in at least some instances, were contemporary with known human activity (e.g. Selby *et al.* 2005; 2010; Gearey *et al.* 2010). These have been suggested as deliberate attempts by Mesolithic hunter-gather communities to encourage or exploit open habitats (Warren *et al.* 2014) to facilitate hunting (Mellars 1976; Simmons and Innes 1996) or the growth of wild foodstuffs (Bye 1981; Smith 2011), such as hazelnuts, or for social purposes (Davies *et al.* 2005). However, the suggestion that pre-'Elm Decline' vegetation instability was as a result of a deliberate attempt to create or maintain natural open habitats at Arderrawinny appears unlikely given the absence of large herbivores in Ireland. Woodman *et al.* (1997) refutes the notion that Mesolithic people in Ireland would have reason to create or maintain open habitats given this absence. When one considers the reliance of Mesolithic hunter-gathers on wild pig in Ireland, a more scrub-like environment would appear more beneficial.

The possibility that these openings were created or maintained out of social or 'ritual' necessity is certainly appealing, given the Neolithic tomb in the area. However, considering the time lapse between these two events of over one thousand years, it is debatable whether the social significance of the landscape would have remained in place for this long. Although it should be stated that there is evidence for the continued use and reuse of particular landscapes and monuments of prehistoric importance (e.g. Brindley and Lanting 1992; O'Brien 1999; Brindley *et al.* 2005; Schulting *et al.* 2012; Bayliss and O'Sullivan 2013). Therefore, despite suggestions of Late Mesolithic environmental impact elsewhere on the peninsula (Mighall *et al.* 2008), it would appear more plausible that the open habitats at Arderrawinny were as a result of the coastal environment and local edaphic conditions, rather than a deliberate attempt by Mesolithic people to create or maintain natural woodland openings. This is further supported by the prolonged duration of the phase of openness in contrast the more episodic nature of suggested clearances exhibited elsewhere (e.g. Fossitt 1994; Mighall *et al.* 2008). It is highly unlikely that any such Mesolithic activity would be of a continued length as exhibited in the pollen record from Arderrawinny.

The significance of cereal-type pollen recorded at *5650 – 5350 cal BC* is also highly debatable. While pre-'Elm Decline' cereal-type pollen has been recorded from several pollen profiles from Ireland (e.g. Lynch 1981; Edwards and Hirons 1984; O'Connell 1987; O'Connell and Molloy 2001; Molloy and O'Connell 2004; Ghilardi and O'Connell 2013) these can largely be dismissed as large pollen grains produced by non-cultivated grasses. Analysis of cereal macrofossils from archaeological contexts strongly suggests that cereal cultivation in Britain and Ireland does not pre-date 4000 cal BC (Brown 2007) and indeed places it several centuries later at *c.*3750 cal BC (Cooney *et al.* 2011; McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). This occurrence of early cereal-type pollen cannot therefore be considered reliable evidence for arable activity and the pre-'Elm Decline' cereal-type pollen at Arderrawinny represents large non-cultivated grass pollen, such as floating sweet grass, which is likely given the context. (This will be discussed further in **Chapter 8**).

There is clear evidence for Early Neolithic activity, in the form of a solitary portal tomb, at Arderrawinny. Despite this, the palynological evidence for Early Neolithic activity is less conclusive and less visible in contrast to the well-defined *Landnam* phases that characterise pollen studies from elsewhere in Ireland (e.g. Pilcher and Smith 1979; O'Connell 1990; O'Connell and Molloy 2001). This would suggest that Early Neolithic activity at Arderrawinny was minimal or of such a small scale as to be difficult to detect palynologically. Alternatively, the relative open nature of the local environment at Arderrawinny may hinder the detection of Early Neolithic activity.

At Arderrawinny herbaceous taxa indicative of potential anthropogenic activity was exhibited continuously until *3540 – 3017 cal BC.* This indicates that woodland openness at Arderrawinny, as signified by the presence of ribwort plantain, probably began in the Late Mesolithic and continued uninterrupted until the Middle/Late Neolithic. Despite this, various peaks in percentage values were evidenced, which may indicate intensified phases of woodland openness and potential evidence for anthropogenic activity. The largest percentage representation was recorded at *3950 – 3720 cal* BC, a second peak was recorded several spectra after the beginning of the 'Elm Decline' at *3810 – 3520 cal BC.* These increases in the representation of ribwort plantain may signify further increased open habitats in an already relatively open landscape, which could possibly relate to Early Neolithic activity in the sampling site basin in association with the nearby portal tomb. (See **Chapter 7**).

This potential evidence for Neolithic activity comes to an end from *3540 – 3070 cal BC*, when increased woodland cover, especially pine and oak, was exhibited. Evidence for anthropogenic activity at Arderrawinny remained muted until the Chalcolithic/Bronze Age, when cereal-type pollen was recorded at *2400 – 1790 cal BC* and may indicate arable activity in the local landscape during the phase of wedge tomb construction and use (O'Brien 1999). An unburnt human tooth recovered during excavtions at Altar wedge tomb, dated to 2320 – 1780 cal BC (3670±80, *OxA-3289*) (*ibid.*, 134), would futher support a Bronze age presence in the vicinity of Arderrawinny at this time. Renewed anthropogenic activity is also evidenced further north on the peninsula as cereal-type pollen was also recorded at Mount Gabriel 1 during the Middle to Late Bronze Age (Mighall and Lageard 1999, 56), while ribwort plantain was again recorded continuously at Arderrawinny from *1610 – 1430 cal BC*. This continuous presence of ribwort plantain would infer increased grassland habitats in the local landscape, while herbaceous taxa more indicative of grazed swards such as clover may indicate the presence of Late Bronze Age farming in the region. A similar signal for Bronze farming was also noted at Cadogan's Bog from 1740 – 1420 cal BC (3280±70, *Beta-122058*) (*ibid.*, 56), which indicates that agricultural was being practiced across the Mizen peninsula at this time.

6.5. Conclusion.

The results of detailed palynological investigations reported here demonstrate that the vegetation history of Arderrawinny was somewhat unusual in an Irish context. It is clear that the coastal environment and local edaphic conditions had a major influence on woodland dynamics throughout the Holocene. The level of woodland openness, though not entirely unique, is rare in Irish contexts. The degree of vegetation openness strongly suggests that the landform unit of the sampling basin and local edaphic conditions had a major influence on woodland dynamics throughout the Holocene.

Despite clear Neolithic activity in the archaeological record, the palynological record was less conclusive and a distinct *Landnam* phase was not identified at Arderrawinny. Evidence for anthropogenic activity in the Neolithic was noted but no conclusive evidence to suggest cereal cultivation or settlement in the area surrounding the megalithic tomb was provided. This difficulty in detecting Early Neolithic activity may result from the fact that the local landscape of Arderrawinny remained quite open for much of the early and mid-Holocene, and as such obscured the palynological signal for any early farming community which may have existed in the vicinity of the sampling site. Alternatively, the Early Neolithic presence may just have been related to the construction and use of the portal tomb, with habitation and agricultural activity occurring elsewhere.

Chapter 7 - Dating the Early Neolithic in southern Ireland.: Integrated Archaeological and Palaeoenvironmental Bayesian Analyses

7.1. Introduction.

While the previous two chapters have discussed the palaeoenvironmental evidence for the Mesolithic/Neolithic transition in southern Ireland, this chapter focuses on the chronology of this transition in more detail. The chronology of the mid-Holocene 'Elm Decline' and the palaeoenvironmental evidence for changing vegetation dynamics and potential anthropogenic impact at both sites are examined. Palaeoenvironmental evidence of human environmental impact, especially early agriculture, is integrated with the Early Neolithic archaeological record to investigate the chronological relationship between both datasets (**Section 7.3.**). However, before these are outlined, this chapter explores the results from the two sites investigated as part of this research within a regional and island-wide context, to investigate the spatial and chronological pattern of the 'Elm Decline' across the island (**Section 7.2.**).

In order to assess these temporal relationships various Bayesian models were employed, firstly the date ranges for the 'Elm Decline' was examined and the statistical probability of these 'events' being synchronous was assessed using the methodologies outlined in **Section 2.4.7.** Secondly, geographical and topographical parameters were incorporated with the results of the Bayesian models undertaken in **Sections 7.2.2-7.2.5** below, to determine what, if any, spatial pattern could be elucidated for this 'event'. Thirdly, the chronological relationship between the 'Elm Decline' and the initiation of a continuous *Plantago lanceolata* curve was explored to determine whether a connection existed between anthropogenic activity and the mid-Holocene 'Elm Decline'.

Additionally, the palynological evidence of human environmental impact, outlined in **Chapters 5** and **6,** was integrated with the Early Neolithic archaeological record to investigate the relationship between both datasets. This relationship was statistically assessed within a Bayesian framework to establish a greater understanding of the chronology and process of Neolithisation in southern Ireland.

7.2. The mid-Holocene 'Elm Decline' in Ireland.

7.2.1. Introduction.

The following section explores the chronology of the mid-Holocene 'Elm Decline' at Arderrawinny and Lough Cullin within a regional and island-wide context, by comparison with previous palynological studies undertaken across the island. The chronology of this palynological 'event', often temporally associated with the beginning of the Neolithic in Ireland and traditionally viewed as a *'catastrophic, uniform phased event'* (Parker *et al.* 2002, 28; Whitehouse *et al.* 2014), will be explored in greater detail to assess the merits of this supposed synchroneity.

The overwhelming majority of sites reviewed did not produce clear evidence for an 'Elm Decline', were from undated pollen profiles or the resolution of the radiocarbon determinations was low (see **Appendix D** for the list of sites excluded). Thirty-nine sites did however, produced evidence for the 'Elm Decline' which have been sufficiently well dated to allow for a robust evaluation of the chronology of this palynological 'event'. Initial assessment of these sites demonstrated a considerable variation in the temporal nature of this 'event' on an island-wide scale (see Table 7.1 & Figure 7.1). Therefore, in order to provide a more robust evaluation of this, the 'Elm Decline' was assessed at the regional levels of Ireland South, North, East and West. The results of which are outlined below.

Site	Metres OD	BP Date	Calibrated Date/*Posterior Density Estimate* (cal BC)					
			from	to	%	from	to	%
Ireland South								
PDE Arderrawinny	0-50	N/A	*3910*	*3710*	*68.2*	*3940*	*3620*	*95.4*
Knockadoon South (Beta-46125)	50-100	5135±65	4035	3804	68.2	4221	3717	95.4
PDE Lough Cullin	0-50	N/A	*4190*	*3980*	*68.2*	*4320*	*3960*	*95.4*
Ireland North								
PDE Ballynagilly	200-250	N/A	*4090*	*3820*	*68.2*	*4300*	*3790*	*95.4*
PDE Ballyscullion	0-50	N/A	*3790*	*3720*	*68.2*	*3820*	*3670*	*95.4*
PDE Beaghmore	150-200	N/A	*4130*	*3980*	*68.2*	*4230*	*3950*	*95.4*
Derryandoran (UB-2234)	50-100	4860±90	3762	3526	68.2	3932	3376	95.4
PDE Fallahogy	0-50	N/A	*4050*	*3980*	*68.2*	*4140*	*3950*	*95.4*
Killymaddy Lough (UB-2475)	50-100	5050±95	3958	3716	68.2	4040	3651	95.4
Lackan 1 (UB-801)	50-100	5085±45	3956	3804	68.2	3973	3780	95.4
Lough Catherine IV (UB-2266)	50-100	5190±95	4226	3812	68.3	4259	3776	95.4
Lough Muckno (UBA-26864)	100-150	5174±40	4039	3956	68.2	4052	3811	95.4
Lough Mullaghlahan (Q-2849)	0-50	5300±50	4229	4050	68.2	4260	3990	95.4
Meenadoan (UB-2109)	200-250	4810±125	3709	3378	68.2	3943	3348	95.4

Site	Metres OD	BP Date	Calibrated Date/*Posterior Density Estimate* (cal BC)					
			from	to	%	from	to	%
Ireland North (continued)								
Slieve Croob (UB-833)	+250	4685±85	3627	3369	68.2	3652	3121	95.4
Slieve Gallion (UB-275)	+250	4895±65	3764	3637	68.2	3914	3525	95.4
Sluggan Bog (UB-441)	0-50	4965±75	3904	3655	68.2	3946	3642	95.4
Weir's Lough (UB-2488)	50-100	5295±85	4236	4002	68.2	4327	3969	95.4
Ireland East								
Clara Bog (Beta-78893)	50-100	5210±80	4228	3964	68.2	4317	3825	95.4
Clowanstown (NZA-34452)	100-150	4360±20	3011	2918	68.2	3022	2911	95.4
Corlea 9 (GU-2141)	50-100	5100±70	3968	3800	68.2	4041	3712	95.4
PDE Derragh Bog	50-100	N/A	*3630*	*3480*	*68.2*	*3660*	*3400*	*95.4*
Kelly's Lough (ß-165541)	+250	5430±50	4339	4252	68.2	4365	4072	95.4
Ireland West								
PDE Ballinphuill	100-150	N/A	*3940*	*3690*	*68.2*	*4140*	*3570*	*95.4*
Ballygalway Lough (LU-2224)	0-50	5210±60	4222	3958	68.2	4233	3819	95.4
PDE Caheraphuca Lough	0-50	N/A	*3720*	*3460*	*68.2*	*3960*	*3390*	*95.4*
PDE Connemara National Park (FRK II)	50-100	N/A	*3470*	*3190*	*68.2*	*3630*	*3130*	*95.4*
PDE Cooney Lough	0-50	N/A	*3930*	*3660*	*68.2*	*4220*	*3650*	*95.4*
Crocknaraw (GrN-21640)	100-150	4030±60	2831	2471	68.2	2864	2350	95.4
PDE Garrynagran	50-100	N/A	*4100*	*3860*	*68.2*	*4220*	*3720*	*95.4*
PDE Glenulra Basin	50-100	N/A	*3730*	*3580*	*68.2*	*3800*	*3530*	*95.4*
Gortalecka	0-50	5240±120	4236	3958	68.2	4334	3797	95.4
Lough Aisling (GrN-13014)	0-50	4970±60	3892	3662	68.2	3942	3647	95.4
PDE Lough Dargan	50-100	N/A	*3960*	*3770*	*68.2*	*3990*	*3540*	*95.4*
PDE Loughmeenaghan	50-100	N/A	*3890*	*3780*	*68.2*	*3960*	*3740*	*95.4*
Lough Namackanbeg (GrN-13024)	50-100	5420±110	4359	4067	68.2	4460	3991	95.4
PDE Lough Sheeauns	0-50	N/A	*3930*	*3750*	*68.2*	*4000*	*3670*	*95.4*
PDE Templevanny Lough	10-150	N/A	*3970*	*3910*	*68.2*	*4010*	*3780*	*95.4*
Treanscrabbagh (LU-2239)	+250	5270±60	4228	3996	68.1	4252	3969	95.4

Table 7.1 PDEs/calibrated radiocarbon date ranges for the mid-Holocene 'Elm Decline' from pollen records across Ireland, where the date range for the 'Elm Decline', at 95.4% probability, is less than c.600 years

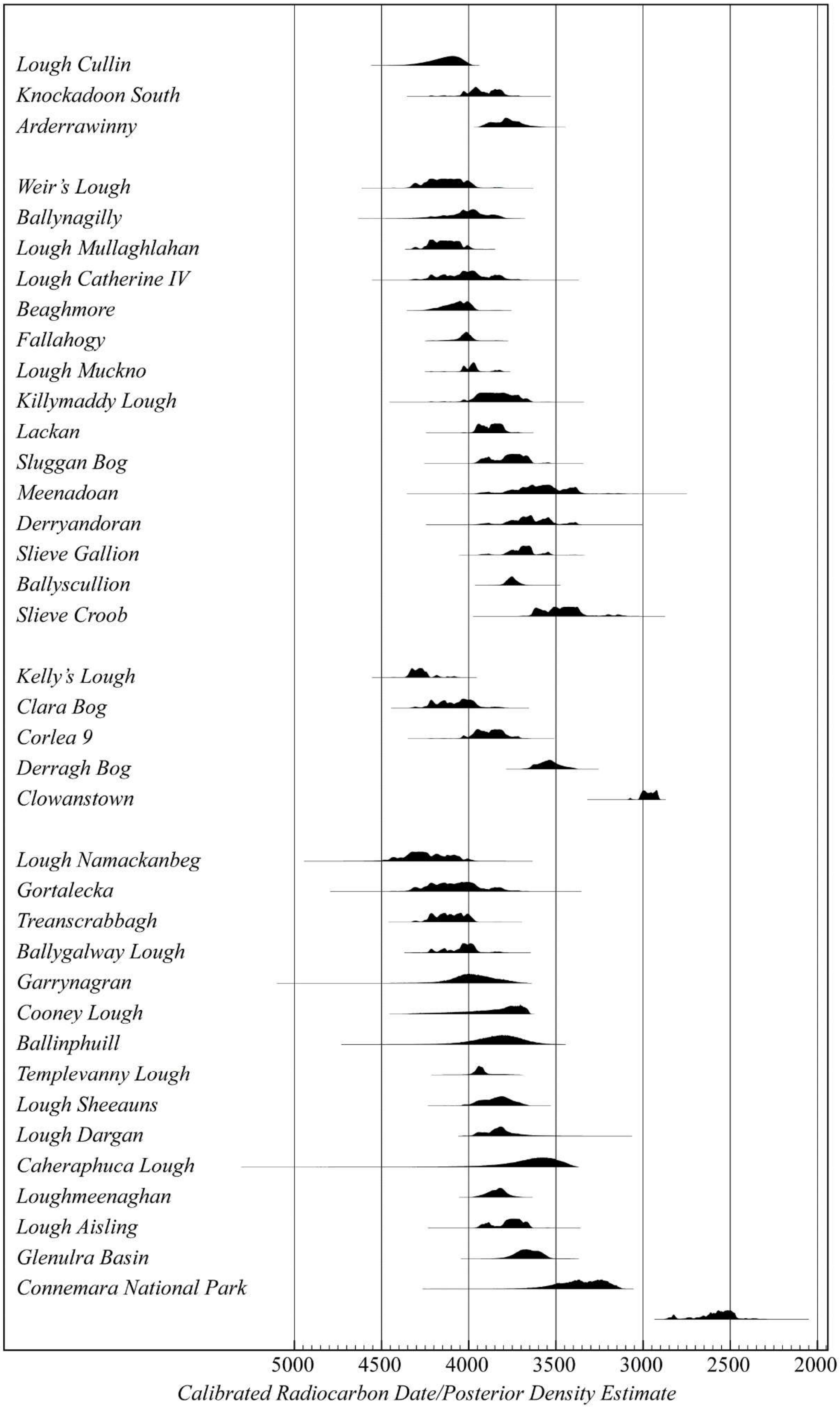

Figure 7.1 Calibrated date/PDE for the mid-Holocene 'Elm Decline' in Ireland South/North/East/West

7.2.2. Ireland South.

In this section Ireland South refers to the study region investigated in this research, which covers Counties Kerry, Cork, Waterford, Limerick, in addition to south Counties Tipperary and Kilkenny. The date range for the start of the mid-Holocene ‘Elm Decline’ at the Lough Cullin, County Kilkenny (this study), Knockadoon South, County Limerick, (Almgren 1989; 2001; Ahlberg *et al.* 2001) and Arderrawinny, County Cork (this study), were assessed to explore the synchroneity of this ‘event’ in the region.

The calibrated radiocarbon date range/*posterior density estimate* for the start of the ‘Elm Decline’ at the three sites indicates that the earliest date for a sustained reduction in *Ulmus* values was at Lough Cullin, which was date to *4320 – 3960 cal BC*, while the latest occurrence was at Arderrawinny, which has been dated to *3930 – 3640 cal BC* (see Table 7.1 & Figure 7.1). To assess the synchroneity of this ‘event’ in the region, the difference (in years) between the date ranges of the ‘Elm Decline’ at Lough Cullin and each of the other sites was established to determine the interval between the onset of the ‘event’ at each site.

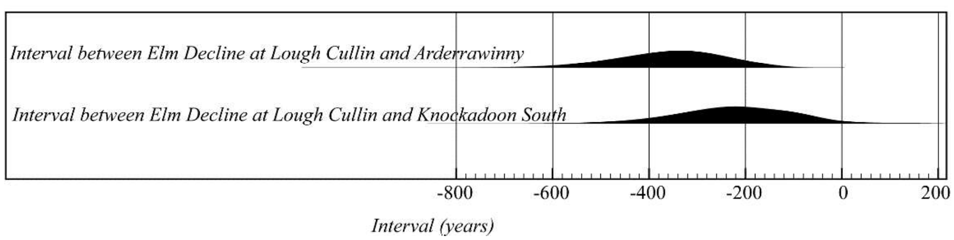

Figure 7.2 Interval between start date for the mid-Holocene ‘Elm Decline’ at sites in Ireland South

Interval between the Elm Decline at Lough Cullin and:	*Interval (years)*					
	from	to	%	from	to	%
Arderrawinny	*-460*	*-220*	*68.2*	*-600*	*-130*	*95.4*
Knockadoon South	*-340*	*-80*	*68.2*	*-490*	*20*	*95.4*

Table 7.2 Interval between start date for the mid-Holocene ‘Elm Decline’ at sites in Ireland South (+ indicates before, - indicates after)

The model demonstrated that the ‘Elm Decline’ at Arderrawinny occurred *130 – 600* years after its occurrence at Lough Cullin (see Table 7.2). This is supported by the statistical probability of 'event' order for the mid-Holocene ‘Elm Decline’ in Ireland South (see Table 7.6). At Knockadoon South, the model suggests that the ‘Elm Decline’ occurred between *20* years before and *490* years after Lough Cullin. This may indicate the possibility that the 'Elm Decline' at these sites may have been contemporary, however, the model also suggests a statistical probability of 96.86% that the 'Elm Decline' occurred at Lough Cullin prior to Knockadoon South (see Table 7.6). The model further suggests that based on the statistical probability of 'event' order in the region, none of the 'Elm Declines' included here appear to have been contemporary and would imply a distinct lack of synchroneity of this 'event' in southern Ireland (see Table 7.6).

7.2.3. Ireland North.

Ireland North refers to palaeoenvironmental sites in the nine counties of the province of Ulster. Fifteen sites were identified for inclusion in the model based on the methodologies outlined in **Section 2.4.8**. The calibrated radiocarbon date range/*posterior density estimate* for the start of the 'Elm Decline' in Ireland North indicates that the earliest sustained reduction in *Ulmus* values was at Weir's Lough (Hirons and Edwards 1986; Hirons and Thompson 1986), which has been radiocarbon dated to 4330 – 3960 cal BC (5295±85, *UB-2488*), while the latest occurrence was at Slieve Croob (Holland 1975) which has been radiocarbon dated to 3660 – 3120 cal BC (4685±85, *UB-833*) (see Table 7.1 & Figure 7.1).

To assess the synchroneity of this 'event' in the region, the difference (in years) between the date ranges of the 'Elm Decline' at Ballyscullion (Smith *et al.* 1971; Smith 1975) and each of the other sites was established to determine the interval between the onset of the 'Elm Decline' at each site. The 'Elm Decline' at Ballyscullion, which has been dated to *3820 – 3670 cal BC*, represent the shortest date range for this 'event' in the region and was therefore chosen as the comparative site for determining the difference between the date ranges for the 'Elm Decline' in Ireland North. The model demonstrated that the 'Elm Decline' occurred at seven sites prior to its occurrence at Ballyscullion. The 'Elm Decline' was demonstrated to have occurred *190 – 590* years at Weir's Lough, *20 – 560* years at Ballynagilly (Pilcher and Smith 1979), *220 – 540* years at Lough Mullaghlahan (Fossitt 1994), *0 – 530* years at Lough Catherine VI (Thompson and Edwards 1982; Hirons and Edwards 1986), *170 – 510* years at Beaghmore (Pilcher 1969), *160 – 410* at Fallahogy (Smith 1957; Smith and Willis 1961) and *50 – 340* years at Lough Muckno (Chique *et al.* 2017) prior to at Ballyscullion. In contrast the 'Elm Decline' at

Slieve Croob (Holland 1975) was shown to have occurred *70 – 630* years after its occurrence at Ballyscullion.

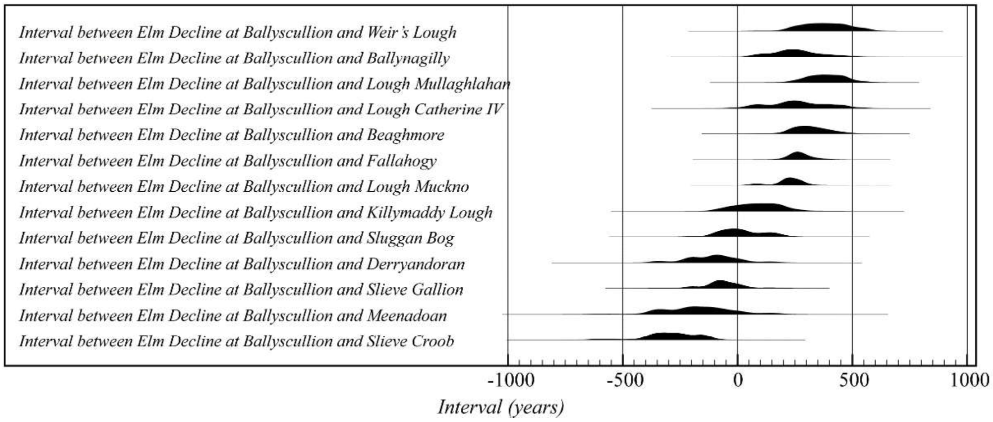

Figure 7.3 Interval between start date for the mid-Holocene 'Elm Decline' at sites in Ireland North

The model demonstrated that the 'Elm Decline' at the remaining six sites, Derryandoran (Pilcher and Larmour 1982, 292) , Killymaddy Lough (Hirons 1983; 1984; Hirons and Edwards 1986), Lackan 1 (Holland 1975), Meenadoan (Pilcher and Larmour 1982), Sluggan Bog (Smith and Goddard 1991) and Slieve Gallion (Pilcher 1973) may have been contemporary with Ballyscullion (see Table 7.3). However, the model also suggests a statistical probability that the 'Elm Decline' occurred at Killymaddy Lough and Lackan 1 prior to at Ballyscullion, while at Derryandoran, Meenadoan and Slieve Gallion it was more probable to have occurred after Ballyscullion (see Table 7.6-Table 7.8). The model did however suggest that the 'Elm Decline' is statistically more probable to have occurred contemporaneously at Sluggan Bog and Ballyscullion (see Table 7.6-Table 7.8). The model further demonstrated a statistical consistency between the date ranges for the 'Elm Decline' at Lough Mullaghlahan and Weir's Lough, Ballynagilly and Lough Catherine VI and between Lough Catherine IV and Fallahogy. However, none of these four statistically consistent 'groups' were shown to have been statistically consistent with each other. This would suggest that despite a degree of synchroneity among certain sites, there was a distinct overall lack of synchroneity among the date ranges for the 'Elm Decline' in the northern region of Ireland (see Table 7.6-Table 7.8).

Interval between the Elm Decline at Ballyscullion and:	*Interval (years)*					
	from	to	%	from	to	%
Weir's Lough	*270*	*490*	*68.2*	*190*	*590*	*95.4*
Ballynagilly	*90*	*350*	*68.2*	*20*	*560*	*95.4*
Lough Mullaghlahan	*290*	*470*	*68.2*	*220*	*540*	*95.4*
Lough Catherine IV	*70*	*420*	*68.2*	*0*	*530*	*95.4*
Beaghmore	*220*	*390*	*68.2*	*170*	*510*	*95.4*
Fallahogy	*210*	*320*	*68.2*	*160*	*410*	*95.4*
Lough Muckno	*180*	*290*	*68.2*	*50*	*340*	*95.4*
Lackan 1	*50*	*190*	*68.2*	*-10*	*250*	*95.4*
Killymaddy Lough	*-20*	*200*	*68.2*	*-110*	*300*	*95.4*
Sluggan Bog	*-100*	*160*	*68.2*	*-140*	*220*	*95.4*
Derryandoran	*-230*	*0*	*68.2*	*-390*	*170*	*95.4*
Slieve Gallion	*-130*	*20*	*68.2*	*-250*	*160*	*95.4*
Meenadoan	*-370*	*-30*	*68.2*	*-430*	*180*	*95.4*
Slieve Croob	*-390*	*-140*	*68.2*	*-630*	*-70*	*95.4*

Table 7.3 Interval between start date for the mid-Holocene 'Elm Decline' at sites in Ireland North (+ indicates before, - indicates after)

7.2.4. Ireland East.

Ireland East refers to palaeoenvironmental sites in the twelve counties of the province of Leinster, with the exception of Lough Cullin, which despite being in County Kilkenny, was undertaken as part of this study and was therefore included in Ireland South. Five sites were identified for inclusion in the model based on the methodologies outlined in **Section 2.4.8.**. The calibrated radiocarbon date range/*posterior density estimate* for the start of the 'Elm Decline' in Ireland East indicates that the earlier expression of a sustained reduction in *Ulmus* values was at Kelly's Lough (Leira *et al.* 2007) which has been radiocarbon dated to 4370 – 4070 cal BC (5430±50, *ß-165541*), while the latest occurrence was at Clowanstown (Gearey *et al.* 2010), which has been radiocarbon dated to 3030 – 2910 cal BC (4360±20, *NZA-34452*) (see Table 7.1 & Figure 7.1).

To assess the synchroneity of this 'event' in the region, the difference (in years) between the date ranges of the 'Elm Decline' at Kelly's Lough and each of the other sites was established to determine the interval between its onset at each site. The model demonstrated that the ‘Elm Decline’ at Corlea 9 (Caseldine and Hatton 1996) occurred *180 – 610* years after the date for this ‘event’ at Kelly’s Lough, while it occurred *540 – 920* years after Kelly’s Lough at Derragh Bog (Selby *et al.* 2005; Brown *et al.* 2005) and *1130 – 1440* years after Kelly’s Lough at Clowanstown. The model suggests that the ‘Elm Decline’ at Clara Bog (Connolly 1999; Crushell *et al.* 2008) occurred between *60* years before or *440* years after the date for this ‘event’ at Kelly’s Lough (see Table 7.4). This may indicate the possibility that the ‘Elm Decline’ at these sites may have been contemporary, however, the model also suggests a statistical probability of 94.67% that the ‘Elm Decline’ occurred at Kelly’s Lough prior to Clara Bog. The model further suggests that based on the statistical probability of ‘event’ order in the region, none of the ‘Elm Declines’ included here appear to have been contemporary and would imply a distinct lack of synchroneity of this ‘event’ in the eastern region of Ireland (see Table 7.9).

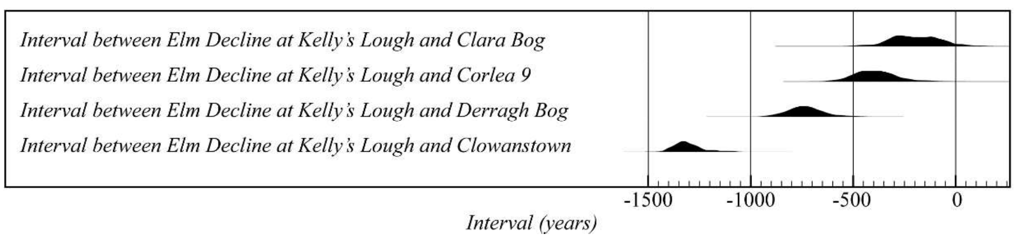

Figure 7.4 Interval between start date for the mid-Holocene ‘Elm Decline’ at sites in Ireland East

Interval between the Elm Decline at Kelly’s Lough and:	*Interval (years)*					
	from	to	%	from	to	%
Clara Bog	*-330*	*-80*	*68.2*	*-440*	*60*	*95.4*
Corlea 9	*-500*	*-300*	*68.2*	*-610*	*-180*	*95.4*
Derragh Bog	*-830*	*-650*	*68.2*	*-920*	*-540*	*95.4*
Clowanstown	*-1380*	*-1250*	*68.2*	*-1440*	*-1130*	*95.4*

Table 7.4 Interval between start date for the mid-Holocene ‘Elm Decline’ at sites in Ireland East (+ indicates before, - indicates after)

7.2.5. Ireland West.

Ireland West refers to the region west of the River Shannon, which covers counties Clare, Galway, Mayo, Leitrim, Roscommon and Sligo. Sixteen sites were identified for inclusion in the model based on the methodologies outlined in **Section 2.4.8.**. The calibrated radiocarbon date range/*posterior density estimate* for the start of the 'Elm Decline' in Ireland West indicates that the earlier date for a sustained reduction in *Ulmus* values was at Lough Namackanbeg (O'Connell and Molloy 1988) which has been dated to *4460 – 3980 cal BC*, while the latest occurrence was at Crocknaraw (Jennings 1997) which has been radiocarbon dated to 2870 – 2350 cal BC (4030±60, *GrN-21640*) (see Table 7.1 & Figure 7.1).

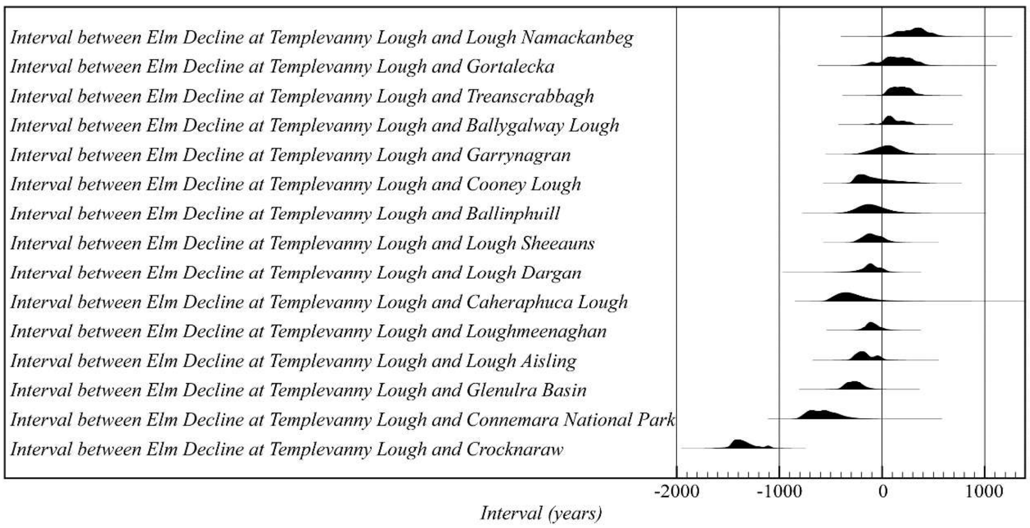

Figure 7.5 Interval between start date for the mid-Holocene 'Elm Decline' at sites in Ireland West

To assess the synchroneity of this 'event' in the region, the difference (in years) between the date ranges of the 'Elm Decline' at Templevanny Lough (Stolze 2012b; Stolze *et al.* 2013a; 2013b) and each of the other sites was established to determine the interval between the onset of the 'Elm Decline' at each site. The 'Elm Decline' at Templevanny Lough was dated to *4010 – 3780 cal BC.* This represented the narrowest date range for this 'event' in the region and was therefore chosen as the comparative site for determining the difference between the date ranges for the 'Elm Decline' in Ireland West. The model demonstrated that the 'Elm Decline' at two sites, Lough Namackanbeg and Treanscrabbagh (Göransson 1984; 2002), was definitively earlier than at Templevanny Lough. This 'event' was shown to have occurred *40 – 560* years earlier at Lough Namackanbeg and *10 – 370* years earlier at Treanscrabbagh than at Templevanny Lough. The model also demonstrated that the 'Elm Decline' occurred *80 – 420* years at Glenulra Basin (Molloy and O'Connell 1995b; O'Connell and Molloy 2001), *240 – 820* years at Connemara National Park (O'Connell and Molloy 1988) and *1070 – 1530* years at Crocknaraw (Jennings 1997) after its occurrence at Templevanny Lough.

Interval between the Elm Decline at Templevanny Lough and;	*Interval (years)*					
	from	to	%	from	to	%
Lough Namackanbeg	*140*	*430*	*68.2*	*40*	*560*	*95.4*
Gortalecka	*10*	*310*	*68.2*	*-170*	*420*	*95.4*
Treanscrabbagh	*70*	*270*	*68.2*	*10*	*370*	*95.4*
Ballygalway Lough	*10*	*220*	*68.2*	*-130*	*320*	*95.4*
Garrynagran	*-90*	*170*	*68.2*	*-270*	*400*	*95.4*
Cooney Lough	*-280*	*20*	*68.2*	*-310*	*320*	*95.4*
Ballinphuill	*-250*	*20*	*68.2*	*-370*	*220*	*95.4*
Lough Sheeauns	*-190*	*0*	*68.2*	*-270*	*100*	*95.4*
Lough Dargan	*-180*	*20*	*68.2*	*-430*	*120*	*95.4*
Caheraphuca Lough	*-470*	*-200*	*68.2*	*-550*	*70*	*95.4*
Loughmeenaghan	*-160*	*-30*	*68.2*	*-220*	*60*	*95.4*
Lough Aisling	*-270*	*-20*	*68.2*	*-310*	*20*	*95.4*
Glenulra Basin	*-350*	*-200*	*68.2*	*-420*	*-80*	*95.4*
Connemara National Park	*-740*	*-440*	*68.2*	*-820*	*-240*	*95.4*
Crocknaraw	*-1470*	*-1280*	*68.2*	*-1530*	*-1070*	*95.4*

Table 7.5 Interval between start date for the mid-Holocene 'Elm Decline' at sites in Ireland West (+ indicates before, - indicates after)

The model demonstrated that the 'Elm Decline' at the remaining nine sites, Gortalecka (Watts 1963; 1984b), Ballygalway Lough (Göransson 1984; 2002), Garrynagran (Jennings 1997), Cooney Lough (Ghilardi 2012), Ballinphuill (Molloy *et al.* 2014), Lough Sheeauns (Molloy and O'Connell 1991), Lough Dargan (Ghilardi 2012; Ghilardi and O'Connell 2013; Taylor *et al.* 2013), Caheraphuca Lough (Molloy and O'Connell 2011), Loughmeenaghan (Stolze 2012b; Stolze *et al.* 2012) and Lough Aisling (Coxon and Browne 1991), may have been contemporary with Templevanny Lough (see Table 7.5). However, the model also suggests the 'Elm Decline' at Ballinphuill, Caheraphuca, Cooney Lough, Lough Aisling, Lough Dargan, Loughmeenaghan and Lough Sheeauns that the 'Elm Decline' occurred at these sites after its occurrence at Templevanny Lough, while Ballygalway, Garrynagran and Gortalecka were shown to have exhibited a sustained reduction in *Ulmus* values prior to at Templevanny Lough (see Table 7.10-Table 7.12). The full statistical model demonstrated an overall lack of synchroneity among the date ranges for the mid-Holocene 'Elm Decline' in the western region of Ireland, with only five sites, Ballinphuill, Cooney Lough, Lough Dargan, Loughmeenaghan and Lough Sheeauns, demonstrating a statistical probability of the 'Elm Decline' having occurred contemporaneously.

Probability t1 is before t2					
t2	Lough Cullin	Knockadoon South	Arderrawinny	Weir's Lough	Ballynagilly
t1					
Lough Cullin		96.93	100	50.75	81.44
Knockadoon South	3.07		88.29	5.34	27.27
Arderrawinny	0	11.71		0.28	3.76
Weir's Lough	49.25	94.66	99.72		77.91
Ballynagilly	18.56	72.72	96.72	22.09	
Lough Mullaghlahan	51.96	96.73	100	50.24	80.26
Lough Catherine IV	21.82	72.54	93.61	24.02	51.34
Beaghmore	27.12	91.72	99.69	31.43	68.53
Fallahogy	9.67	87.07	99.76	15.94	57.33
Lough Muckno	3.20	75.26	96.76	8.29	44.6
Killymaddy Lough	1.21	28.83	68.20	2.21	14.23
Lackan	0.02	33.71	82.76	0.92	14.72
Meenadoan	0.02	2.83	11.43	0.09	1.11
Sluggan Bog	0.01	12.58	45.14	0.32	5.25
Derryandoran	0.01	2.87	14.85	0.07	1.01
Slieve Gallion	0	2.61	18.71	0.06	1.03
Ballyscullion	0	2.55	35.64	0.03	0.70
Slieve Croob	0	0.01	0.37	0	0.01
Kelly's Lough	88.30	99.72	100	88.4	94.76
Clara Bog	33.29	88.34	98.97	35.63	67.26
Corlea 9	1.18	38.02	81.45	2.49	18.71
Derragh Bog	0	0.01	0.68	0	0.01
Clowanstown	0	0	0	0	0
Lough Namackanbeg	73.81	98.21	99.95	74.12	89.06
Gortalecka	36.04	81.88	95.63	37.71	63.6
Treanscrabbagh	41.76	94.57	99.94	43.01	75.45
Ballygalway Lough	20.99	85.02	98.80	24.51	59.71
Garrynagran	11.97	64.53	91.17	14.78	42.05
Cooney Lough	9.41	32.85	60.90	10.23	21.48
Ballinphuill	3.79	28.56	61.85	4.79	16.09
Templevanny Lough	0.26	53.39	95.80	2.01	26.50
Lough Sheeauns	0.37	25.90	68.96	1.24	11.88
Lough Dargan	0.04	22.35	63.98	0.66	9.62
Caheraphuca Lough	1.83	6.7	18.48	1.68	4.05
Loughmeenaghan	0.01	23.39	73	0.62	9.17
Lough Aisling	0	11.16	43.68	0.27	4.61
Glenulra Basin	0	0.79	11.54	0.01	0.24
Connemara National Park	0.01	0.56	0.95	0.06	0.28
Crocknaraw	0	0	0	0	0

Table 7.6 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary)

Probability t1 is before t2						
t2	Lough Mullaghlahan	Lough Catherine IV	Beaghmore	Fallahogy	Lough Muckno	Killymaddy Lough
t1						
Lough Cullin	48.04	78.18	72.87	90.32	96.79	98.69
Knockadoon South	3.27	27.46	8.28	12.93	24.74	71.17
Arderrawinny	0	6.38	0.30	0.23	3.24	31.80
Weir's Lough	49.76	75.98	68.57	84.06	91.71	97.79
Ballynagilly	19.75	48.66	31.46	42.67	55.4	85.77
Lough Mullaghlahan		77.87	72.24	90.05	96.01	98.65
Lough Catherine IV	22.13		35.10	46.78	58.4	84.53
Beaghmore	27.76	64.9		71.94	85.8	96.66
Fallahogy	9.95	53.22	28.05		74.57	95.26
Lough Muckno	3.99	41.61	14.2	25.42		89.95
Killymaddy Lough	1.34	15.47	3.33	4.74	10.04	
Lackan	0.04	16.88	1.11	1.20	6.74	59.78
Meenadoan	0.02	1.51	0.14	0.14	0.88	7.28
Sluggan Bog	0.01	6.55	0.37	0.34	2.13	29.90
Derryandoran	0	1.58	0.07	0.06	0.77	9.23
Slieve Gallion	0	1.54	0.06	0.05	0.37	11.21
Ballyscullion	0	2.04	0.02	0.02	0.14	20.97
Slieve Croob	0	0.01	0	0	0.01	0.16
Kelly's Lough	92.19	96.31	96.98	99.52	99.83	99.87
Clara Bog	34	64.82	51.9	67.55	79.68	94.84
Corlea 9	1.21	20.02	3.74	5.69	13.48	61.49
Derragh Bog	0	0.01	0	0	0	0.28
Clowanstown	0	0	0	0	0	0
Lough Namackanbeg	75.66	88.91	86.71	94.98	97.68	99.25
Gortalecka	36.84	62.35	51.39	63.87	73.02	89.79
Treanscrabbagh	41.71	72.6	62.9	81.33	91.18	97.9
Ballygalway Lough	21.27	56.79	38.06	54.65	72.32	93.65
Garrynagran	12.04	40.65	22.88	33.89	46.3	79.73
Cooney Lough	9.12	22.37	14.47	18.18	24.26	48.04
Ballinphuill	3.85	17.07	6.95	9.73	14.87	46.5
Templevanny Lough	0.33	26.21	2.71	3.41	14.10	78.96
Lough Sheeauns	0.39	13.57	1.83	2.72	7.67	48.93
Lough Dargan	0.05	11.45	0.83	0.97	4.84	44.41
Caheraphuca Lough	1.54	4.39	2.24	2.85	3.82	12.47
Loughmeenaghan	0.02	12.11	0.69	0.71	4.34	49.01
Lough Aisling	0.01	5.92	0.30	0.26	1.85	28.60
Glenulra Basin	0.01	0.61	0.01	0.01	0.08	6.54
Connemara National Park	0.05	0.32	0.10	0.17	0.25	1.20
Crocknaraw	0	0	0	0	0	0

Table 7.7 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

Probability t1 is before t2						
t2	Lackan	Meenadoan	Sluggan Bog	Derryandoran	Slieve Gallion	Ballyscullion
t1						
Lough Cullin	99.97	99.98	99.99	100	100	100
Knockadoon South	66.29	97.16	87.42	97.12	97.39	97.45
Arderrawinny	17.24	88.56	54.86	85.14	81.28	64.36
Weir's Lough	99.08	99.90	99.68	99.92	99.94	99.97
Ballynagilly	85.28	98.89	94.75	98.99	98.97	99.29
Lough Mullaghlahan	99.96	99.98	99.99	100	100	100
Lough Catherine IV	83.12	98.49	93.45	98.42	98.46	97.96
Beaghmore	98.88	99.86	99.63	99.92	99.94	99.98
Fallahogy	98.8	99.85	99.66	99.94	99.95	99.98
Lough Muckno	93.26	99.12	97.86	99.22	99.62	99.85
Killymaddy Lough	40.22	92.72	70.1	90.77	88.79	79.03
Lackan		95.88	81.52	95.77	96.32	96.8
Meenadoan	4.14		13.28	36.73	24.67	12.47
Sluggan Bog	18.47	86.71		82	75.86	53.05
Derryandoran	4.22	63.27	18		35.98	15.91
Slieve Gallion	3.68	75.33	24.13	64.02		19.41
Ballyscullion	3.2	87.52	46.95	84.09	80.58	
Slieve Croob	0.01	26.70	0.51	12.70	3.29	0.07
Kelly's Lough	100	100	100	100	100	100
Clara Bog	96.41	99.69	98.76	99.73	99.78	99.87
Corlea 9	53.26	95.70	81.32	95.38	95.45	93.15
Derragh Bog	0.01	39.83	1.02	20.78	6.16	0.08
Clowanstown	0	0.02	0	0	0	0
Lough Namackanbeg	99.83	99.98	99.94	99.99	99.99	100
Gortalecka	89.32	99	95.72	98.87	98.89	98.31
Treanscrabbagh	99.7	99.95	99.92	99.98	99.99	99.99
Ballygalway Lough	95.78	99.64	98.61	99.70	99.77	99.89
Garrynagran	77.52	97.82	90.97	97.76	97.63	96.32
Cooney Lough	39.39	91.30	64.93	88.42	84.89	68.33
Ballinphuill	37.06	90.03	64.86	86.75	83.58	72.17
Templevanny Lough	78.29	98.41	93.59	98.57	98.86	98.84
Lough Sheeauns	36.86	93.30	71.26	92.18	91.35	83.29
Lough Dargan	32.71	89.90	65.62	87.59	84.31	78.5
Caheraphuca Lough	8.45	59.86	19.82	45.88	32.96	19.43
Loughmeenaghan	34.4	94.16	74.29	93.76	94.46	93.25
Lough Aisling	16.40	87.31	49.86	82.77	77.31	52.39
Glenulra Basin	1.01	69.11	16.21	55.20	38.5	11.31
Connemara National Park	0.72	13.75	2.07	6.33	4.12	1.94
Crocknaraw	0	0	0	0	0	0

Table 7.8 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

Probability t1 is before t2						
t2	Slieve Croob	Kelly's Lough	Clara Bog	Corlea 9	Derragh Bog	Clowanstown
t1						
Lough Cullin	100	11.70	66.71	98.82	100	100
Knockadoon South	100	0.28	11.65	61.98	100	100
Arderrawinny	99.62	0	1.02	18.54	99.32	100
Weir's Lough	100	11.60	64.37	97.51	100	100
Ballynagilly	100	5.24	32.74	81.29	100	100
Lough Mullaghlahan	100	7.80	66	98.79	100	100
Lough Catherine IV	100	3.69	35.18	79.97	99.99	100
Beaghmore	100	3.01	48.1	96.25	100	100
Fallahogy	100	0.48	32.45	94.31	100	100
Lough Muckno	100	0.16	20.31	86.52	100	100
Killymaddy Lough	99.84	0.12	5.16	38.51	99.71	100
Lackan	100	0	3.59	46.74	100	100
Meenadoan	24.67	0	0.30	4.30	60.17	99.97
Sluggan Bog	99.48	0	1.23	18.67	98.98	100
Derryandoran	87.30	0	0.26	4.61	79.22	100
Slieve Gallion	96.7	0	0.22	4.54	93.84	100
Ballyscullion	99.93	0	0.13	6.85	99.91	100
Slieve Croob		0	0.01	0.01	28.63	99.97
Kelly's Lough	100		94.71	99.91	100	100
Clara Bog	100	5.28		93.52	100	100
Corlea 9	99.99	0.09	6.48		99.99	100
Derragh Bog	71.37	0	0	0.01		100
Clowanstown	0.03	0	0	0	0	
Lough Namackanbeg	100	40.44	83.2	99.25	100	100
Gortalecka	100	9.36	49.61	86.98	99.99	100
Treanscrabbagh	100	6.16	58.85	97.8	100	100
Ballygalway Lough	100	2.35	39.1	91.89	100	100
Garrynagran	99.99	2.56	24.57	73.68	99.98	100
Cooney Lough	99.93	2.48	14.71	39.08	99.85	100
Ballinphuill	99.19	1.01	8.15	36.32	98.59	100
Templevanny Lough	100	0.01	7.16	69.88	100	100
Lough Sheeauns	99.97	0.01	3.66	35.94	99.96	100
Lough Dargan	97.33	0	2.41	31.89	95.92	100
Caheraphuca Lough	84	0.66	2.40	8.72	71.96	100
Loughmeenaghan	99.99	0	2.23	34.12	100	100
Lough Aisling	99.82	0	1.02	17.04	99.61	100
Glenulra Basin	94.61	0	0.04	1.86	90.72	100
Connemara National Park	29.74	0.01	0.13	0.76	14.89	100
Crocknaraw	0	0	0	0	0	0

Table 7.9 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

Probability t1 is before t2					
t2	Lough Namackanbeg	Gortalecka	Treanscrabbagh	Ballygalway Lough	Garrynagran
t1					
Lough Cullin	26.19	63.96	58.24	79	88.02
Knockadoon South	1.79	18.11	5.43	14.97	35.47
Arderrawinny	0.04	4.36	0.06	1.20	8.83
Weir's Lough	25.88	62.29	56.99	75.49	85.22
Ballynagilly	10.93	36.4	24.55	40.29	57.95
Lough Mullaghlahan	24.34	63.16	58.29	78.73	87.96
Lough Catherine IV	11.09	37.65	27.39	43.21	59.35
Beaghmore	13.29	48.61	37.1	61.94	77.11
Fallahogy	5.01	36.14	18.66	45.35	66.11
Lough Muckno	2.31	26.97	8.82	27.68	53.7
Killymaddy Lough	0.74	10.21	2.09	6.35	20.27
Lackan	0.16	10.68	0.29	4.21	22.47
Meenadoan	0.02	0.99	0.04	0.35	2.18
Sluggan Bog	0.05	4.28	0.08	1.39	9.02
Derryandoran	0.01	1.13	0.01	0.29	2.23
Slieve Gallion	0.01	1.10	0.01	0.23	2.36
Ballyscullion	0.01	1.69	0.01	0.11	3.68
Slieve Croob	0	0.01	0	0	0.01
Kelly's Lough	59.56	90.64	93.83	97.64	97.44
Clara Bog	16.79	50.39	41.15	60.9	75.43
Corlea 9	0.75	13.02	2.19	8.10	26.32
Derragh Bog	0	0.01	0	0	0.02
Clowanstown	0	0	0	0	0
Lough Namackanbeg		80.36	79.79	89.68	93.48
Gortalecka	19.64		42.59	58.52	71.04
Treanscrabbagh	20.21	57.41		71.71	83.36
Ballygalway Lough	10.32	41.48	28.29		68.27
Garrynagran	6.51	28.95	16.64	31.73	
Cooney Lough	5.16	17.10	11.34	17.38	27.04
Ballinphuill	2.23	11.99	5.12	10.17	21.47
Templevanny Lough	0.42	16.44	1.02	8.19	36.1
Lough Sheeauns	0.31	8.82	0.94	4.57	18.25
Lough Dargan	0.11	7.38	0.27	2.93	15.47
Caheraphuca Lough	0.99	3.30	1.80	2.87	5.44
Loughmeenaghan	0.11	7.76	0.17	2.76	15.92
Lough Aisling	0.04	3.96	0.05	1.15	8.32
Glenulra Basin	0.01	0.49	0.01	0.05	1.02
Connemara National Park	0.02	0.23	0.07	0.16	0.44
Crocknaraw	0	0	0	0	0

Table 7.10 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

Probability t1 is before t2						
t2	Cooney Lough	Ballinphuill	Templevanny Lough	Lough Sheeauns	Lough Dargan	Caheraphuca Lough
t1						
Lough Cullin	90.59	96.20	99.73	99.62	99.96	98.16
Knockadoon South	67.15	71.44	46.61	74.1	77.65	93.3
Arderrawinny	39.10	38.15	4.20	31.03	36.32	81.52
Weir's Lough	89.76	95.21	98	98.76	99.34	98.32
Ballynagilly	78.52	83.9	73.5	88.12	90.37	95.95
Lough Mullaghlahan	90.88	96.15	99.67	99.61	99.95	98.46
Lough Catherine IV	77.62	82.93	73.79	86.43	88.55	95.61
Beaghmore	85.53	93.04	97.29	98.17	99.17	97.75
Fallahogy	81.82	90.27	96.59	97.28	99.02	97.15
Lough Muckno	75.74	85.12	85.89	92.33	95.15	96.18
Killymaddy Lough	51.93	53.50	21.04	51.07	55.59	87.53
Lackan	60.61	62.94	21.71	63.14	67.29	91.54
Meenadoan	8.69	9.96	1.58	6.70	10.09	40.14
Sluggan Bog	35.07	35.14	6.40	28.74	34.38	80.18
Derryandoran	11.57	13.24	1.42	7.82	12.41	54.12
Slieve Gallion	15.10	16.42	1.14	8.64	15.69	67.04
Ballyscullion	31.67	27.82	1.15	16.71	21.50	80.56
Slieve Croob	0.07	0.81	0.01	0.02	2.67	15.99
Kelly's Lough	97.52	98.98	99.99	99.98	100	99.33
Clara Bog	85.29	91.84	92.84	96.34	97.59	97.6
Corlea 9	60.92	63.68	30.11	64.06	68.11	91.27
Derragh Bog	0.14	1.40	0.01	0.04	4.08	28.04
Clowanstown	0	0	0	0	0	0
Lough Namackanbeg	94.83	97.76	99.57	99.68	99.88	99
Gortalecka	82.90	88.01	83.56	91.18	92.61	96.69
Treanscrabbagh	88.66	94.88	98.98	99.05	99.72	98.2
Ballygalway Lough	82.61	89.83	91.81	95.42	97.06	97.12
Garrynagran	72.95	78.53	63.9	81.74	84.53	94.55
Cooney Lough		51.80	29.95	47.74	51.98	85.39
Ballinphuill	48.20		22.92	46.88	51.39	84.79
Templevanny Lough	70.05	77.07		82.17	85.94	94.52
Lough Sheeauns	52.26	53.12	17.83		54.17	88.26
Lough Dargan	48.02	48.61	14.06	45.83		83.36
Caheraphuca Lough	14.61	15.21	5.47	11.74	16.64	
Loughmeenaghan	54.40	54.45	10.01	51.71	55.5	89.46
Lough Aisling	34.59	34.45	5.30	27.08	32.76	80.82
Glenulra Basin	9.32	11.23	0.30	4.41	11.30	60.96
Connemara National Park	0.70	1.60	0.42	1.09	2.59	9.32
Crocknaraw	0	0	0	0	0	0

Table 7.11 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

Probability t1 is before t2					
t2	Loughmeenaghan	Lough Aisling	Glenulra Basin	Connemara National Park (FRK II)	Crocknaraw
t1					
Lough Cullin	99.98	100	99.98	100	100
Knockadoon South	76.6	88.84	99.21	99.44	100
Arderrawinny	27	56.32	88.45	99.04	100
Weir's Lough	99.38	99.73	99.99	99.93	100
Ballynagilly	90.82	95.39	99.76	99.72	100
Lough Mullaghlahan	99.98	100	100	99.95	100
Lough Catherine IV	87.89	94.08	99.39	99.68	100
Beaghmore	99.31	99.7	99.99	99.89	100
Fallahogy	99.28	99.74	99.98	99.83	100
Lough Muckno	95.66	98.15	99.92	99.75	100
Killymaddy Lough	50.99	71.39	93.45	98.8	100
Lackan	65.6	83.6	98.99	99.28	100
Meenadoan	5.83	12.67	30.89	86.25	100
Sluggan Bog	25.70	50.14	83.78	97.93	100
Derryandoran	6.23	17.22	44.80	93.67	100
Slieve Gallion	5.53	22.69	61.5	95.88	100
Ballyscullion	6.75	47.61	88.68	98.05	100
Slieve Croob	0.01	0.18	5.38	70.25	100
Kelly's Lough	100	100	100	100	100
Clara Bog	97.76	98.98	99.95	99.86	100
Corlea 9	65.88	82.95	98.13	99.23	100
Derragh Bog	0.01	0.38	9.27	85.11	100
Clowanstown	0	0	0	0.01	100
Lough Namackanbeg	99.88	99.96	100	99.98	100
Gortalecka	92.23	96.04	99.5	99.77	100
Treanscrabbagh	99.82	99.94	100	99.92	100
Ballygalway Lough	97.23	98.85	99.95	99.83	100
Garrynagran	84.07	91.68	98.97	99.56	100
Cooney Lough	45.60	65.41	90.68	99.29	100
Ballinphuill	45.55	65.55	88.76	98.39	100
Templevanny Lough	89.99	94.69	99.7	99.58	100
Lough Sheeauns	48.29	72.92	95.59	98.9	100
Lough Dargan	44.5	67.24	88.69	97.41	100
Caheraphuca Lough	10.54	19.18	39.04	90.67	100
Loughmeenaghan		76.81	98.12	99.06	100
Lough Aisling	23.19		85.33	98.04	100
Glenulra Basin	1.87	14.67		95.03	100
Connemara National Park	0.94	1.95	4.97		100
Crocknaraw	0	0	0	0	

Table 7.12 Statistical probability of 'event' order for the mid-Holocene 'Elm Decline' in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

7.2.6. The spatial and temporal relationship of the mid-Holocene 'Elm Decline' in Ireland.

The following section examines the chronology of the mid-Holocene 'Elm Decline' on an island-wide scale to determine what, if any, spatial and temporal pattern exists for this palynological 'event' on the island. While the regional analysis, outlined above, has exhibited little evidence for a synchronous *'uniform phased event'* (Parker *et al.* 2002, 28), it is essential to explore this within a spatial framework to determine whether some degree of geographical cohesion can be extrapolated from this chronologically heterogenous 'event'.

The results of the regional evaluation of the timing of the 'Elm Decline' demonstrate that the mid-Holocene reductions in *Ulmus* across Ireland cannot be regarded as rapid or synchronous (cf. Parker *et al.* 2002; Whitehouse *et al.* 2014). The earliest expression of a sustained reduction in *Ulmus* values was at Lough Namackanbeg in Ireland West, while the latest occurrence was at Crocknaraw, also in Ireland West. The interval between the earliest and latest occurrence of the 'Elm Decline' ranged from *1310 – 1980 (95.4% probability), 1490 – 1830 (68.2% probability)* years.

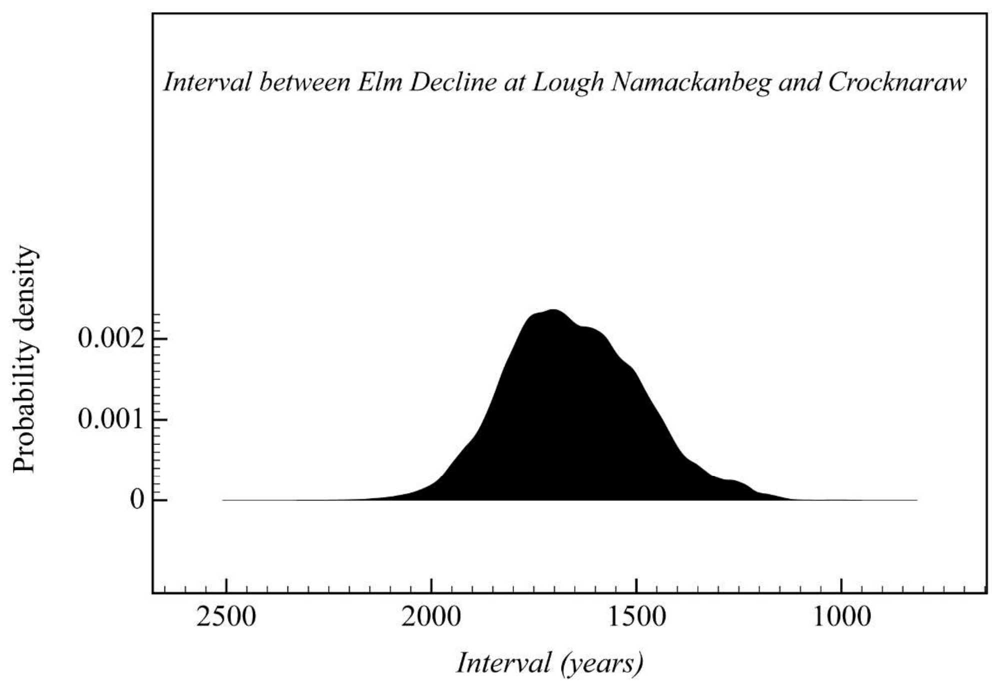

Figure 7.6 Interval between the earliest and latest expression of the 'Elm Decline' in Ireland

This would strongly challenge the perceived chronologically 'fixed' date for the mid-Holocene 'Elm Decline' in Ireland, and strenuously refute the insistence of an island-wide uniform 'event'. However, despite a distinct lack of overall synchroneity for the mid-Holocene 'Elm Decline' across the island demonstrated in the statistical probability model, eight statistically consistent sub-sets were noted. Although none of these sub-sets exhibited a statistical probability of being contemporaneous (see Table 7.6-Table 7.12). The model demonstrated a statistical probability that the calibrated radiocarbon date ranges/*posterior density estimates* for the 'Elm Decline' at Lough Cullin (Ireland South) Weir's Lough (Ireland North) and Lough Mullaghlahan (Ireland North) were contemporaneous (**Group 1**). The model further demonstrated that the 'Elm Decline' at Clara Bog (Ireland East), Beaghmore (Ireland North) and Gortalecka (Ireland West) were statistically more probable to have occurred simultaneously (**Group 2**). A similar synchroneity was noted between the date ranges/*posterior density estimates* for this 'event' at Lough Catherine IV (Ireland North), Ballynagilly (Ireland North) and Fallahogy (Ireland North), while Fallahogy and Ballygalway (Ireland West) were shown to be statistically consistent (**Group 3**).

Further synchroneity between the calibrated date ranges/*posterior density estimates* for the 'Elm Decline' was evidenced at Knockadoon South (Ireland South) and Templevanny Lough (Ireland West) (**Group 4**), Lough Muckno (Ireland North) and Garrynagran (Ireland West) (**Group 5**) and between Killymaddy Lough (Ireland North), Ballinphuill (Ireland West), Cooney Lough (Ireland West), Lough Sheeauns (Ireland West) and Loughmeenaghan (Ireland West). While the date range for this 'event' at Ballinphuill, Cooney Lough and Lough Sheeauns were consistent with the date range for Lough Dargan (Ireland West) (**Group 6).** Three further synchronous 'groups' were evidenced at Corlea 9 (Ireland East) and Lackan 1 (Ireland North) (**Group 7**), Caheraphuca Lough (Ireland West) and Derrandoran (Ireland North) (**Group** 8) and at Sluggan Bog (Ireland North), Ballyscullion (Ireland North) and Lough Aisling (Ireland West), while Sluggan Bog and Arderrawinny (Ireland South) were shown to be statistically consistent (**Group 9**). The calibrated date range/*posterior density estimate* for the mid-Holocene 'Elm Decline' at the remaining eleven sites did not demonstrate a statistical probability of having transpired contemporaneously with any of these groupings or indeed with the calibrated date range/*posterior density estimate* for the 'event' at any site.

In order to determine whether these nine groups exhibited a spatial pattern for the onset of the mid-Holocene ‘Elm Decline’, these sites were plotted geographically (see Figure 7.7) and temporally, with **Group 1** representing the earliest synchronous date ranges and **Group 9**, the latest. However, these temporal demarcations are not in strict succession and a degree of overlap may exist within the various groupings. An initial assessment may imply a certain degree of spatial cohesion at certain sites in the regions of Ireland North and West, however, it must be expressly stated that this may very well result from a distributional bias within the dataset, as thirty-one of the thirty-nine sites included in this model are from within these two regions. Detailed analysis of the geographical distribution of the sites would appear to indicate a distinct lack of an identifiable spatial dynamic to the mid-Holocene ‘Elm Decline’ in Ireland. The three sites in **Group 1**, which exhibit a statistical probability of having a synchronous reduction in *Ulmus* values, demonstrate no spatial cohesion or pattern. While later groups may be said to exhibit a regional or spatial distributional association, such as **Group 3**, which appears to have a northern distribution, or **Group 6**, which has a predominantly western distribution, these also occur in close spatial proximity to sites which demonstrate no temporal consistency for the ‘Elm Decline’ and this spatial cohesion may result from distributional biases within the dataset.

What is apparent from the spatial analysis of sites which exhibit a well-dated expression of the mid-Holocene ‘Elm Decline’ is a conspicuous lack of geographical cohesion. While certain groupings may initially be said to exhibit an element of spatial homogeneity, this interpretation is misleading as the majority sites within these regions exhibit no temporal alignment with these groups. For example, while five of the six sites in **Group 6** are located in the Ireland West region, the remaining twelve sites in this region demonstrate no temporal consistency with these sites. This would question, based on the size of the dataset available, whether a pattern for the spread of the ‘Elm Decline’ can be established along geographical lines.

The effects of further topographical and geographical factors on potential patterns of the ‘Elm Decline’ across the island were also assessed. When the topographical parameter was introduced, the chronological sequence of the ‘Elm Decline’ again displayed little cohesion between sites of varying altitude. **Group 2** sites for example demonstrated no consistency among the sites in term of their altitude in metres OD, despite being statistically shown to have occurred simultaneously. While certain groups were shown to be cohesive in terms of both chronology and altitude, such as **Groups 7** and **9**, the majority of sites at these altitudes were not statistically consistent chronological with either of these groups. Essentially, while all sites in **Group 9** were below 50mOD, these sites only represented *c.*30% of the sites within this range. It is therefore highly questionable whether a pattern for the start and spread of the 'Elm Decline' can be established based on topographical grounds. This is not to state definitively that such a pattern does not exist but merely that the size of the dataset may be insufficient for such as pattern to be elucidated.

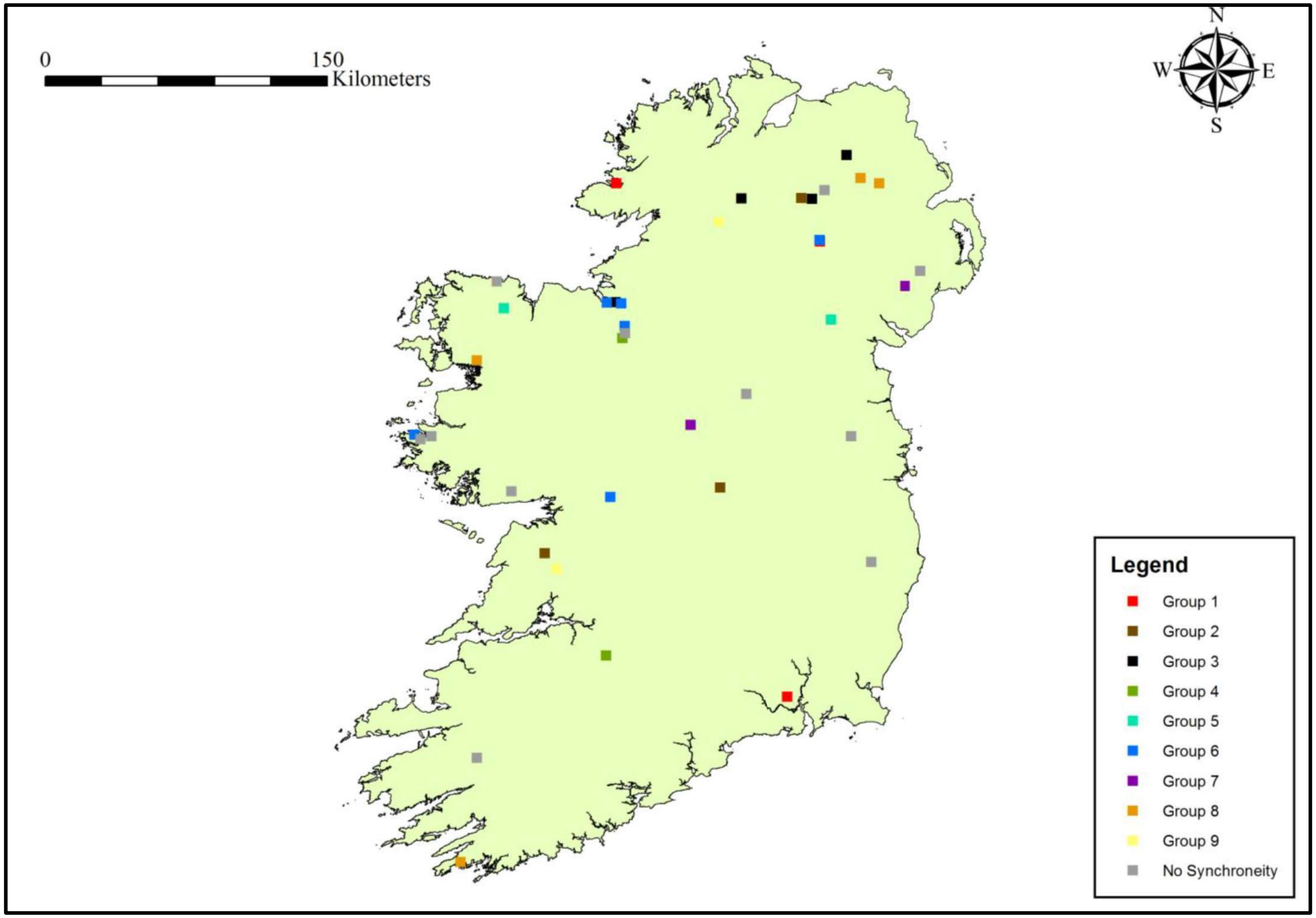

Figure 7.7 Spatial distribution of the statistically probable synchronous 'Elm Decline' 'events' across the island

7.2.7. The ‘expression’ or ‘signature’ of the ‘Elm Decline’ in Ireland

One final aspect of the mid-Holocene decline in *Ulmus* which needs to be considered is to what extent this reduction is expressed in a similar fashion at different locations. It is essential to establish whether, despite a lack of spatial or temporal cohesion, the palynological signal for the ‘Elm Decline’ occurs uniformly at each site, or whether this again infers a more heterogenous ‘event’.

As outlined in **Chapter 5**, the mid-Holocene ‘Elm Decline’ at Lough Cullin occurred with the reduction of *Ulmus* to minimal levels before a later recovery in the taxon, while evidence for open environments are exhibited as *Ulmus* values are reduced. This pattern could be said to represent the ‘classic Elm Decline’ and is exhibited at numerous other sites across the island, such as Ballinphuill (Molloy *et al.* 2014) and Lough Muckno (Chique *et al.* 2017). The ‘classic Elm Decline’ could be characterised by a bowl-shaped reduction in *Ulmus* values (see Figure 7.8 & Figure 7.9). Following the mid-Holocene ‘Elm Decline’ pollen diagrams in Ireland frequently demonstrate evidence for woodland instability and/or early agricultural activity (e.g. Fossitt 1994; Heery 1997; Brown *et al.* 2005; Selby *et al.* 2005; Ghilardi and O'Connell 2013; Molloy *et al.* 2014), which may suggest a connection between anthropogenic activity and the reduction in *Ulmus* values.

However, while this may represent the ‘classic Elm Decline’ various other expressions of the mid-Holocene Elm Decline can be gleaned from pollen profiles elsewhere on the island. At Kelly’s Lough (Leira *et al.* 2007) (see Figure 7.10) or Corlea 9 (Caseldine and Hatton 1996) for example, the reduction in *Ulmus* is not concomitant with increased evidence for woodland openness or anthropogenic activity. Also in contrast to the ‘classic Elm Decline’ is the evidence for multiple fluctuations in *Ulmus* populations exhibited at Knockadoon South (Almgren 1989; 2001), Cornaher Lough (Heery 1997), Clara Bog (Connolly 1999; Crushell *et al.* 2008) and possible from the undated profile from Scragh Bog (O'Connell 1980), while evidence for a reduction in *Ulmus* is not presented at Clowanstown (Gearey *et al.* 2010) or Crocknaraw (Jennings 1997) until much later, and may indicate that no mid-Holocene Elm Decline at these sites. Therefore, while the notion of a ‘classic Elm Decline’ is prevalent at a number of sites, the palynological signal of this ‘event’ is not always expressed in a homogenous, uniform fashion.

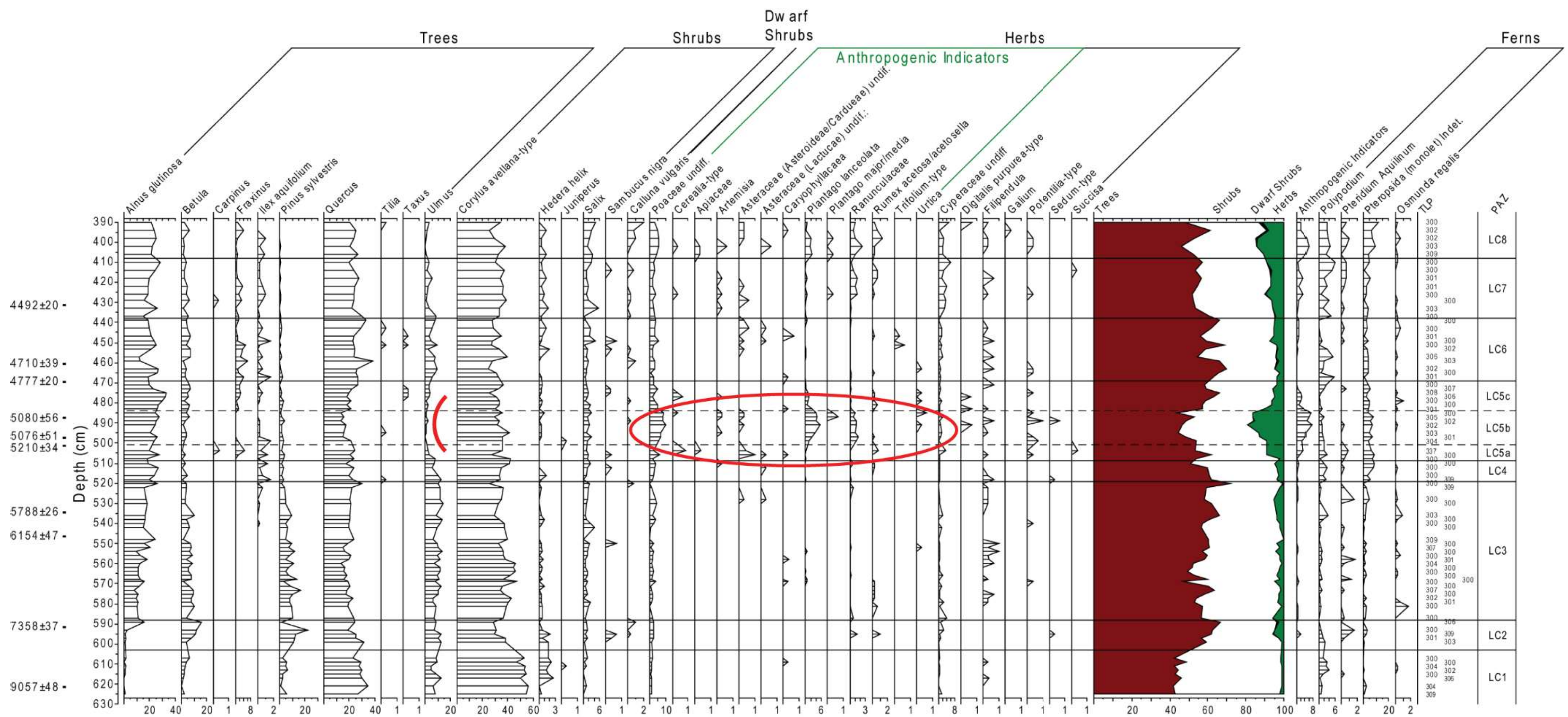

Figure 7.8 'Classic' Elm Decline from Lough Cullin, County Kilkenny

Image Redacted, See Molloy *et al.* (2014, 29)

Figure 7.9 ‘Classic’ Elm Decline from Ballinphuill, County Galway (Molloy et al. 2014)

Image Redacted, See Leira *et al.* (2007, 63)

Figure 7.10 Elm Decline at Kelly's Lough, County Wicklow (Leira et al. 2007)

Image Redacted See, Gearey *et al.* (2010, 21)

Figure 7.11 No mid-Holocene Elm Decline at Clowanstown, County Meath (Gearey et al. 2010)

7.2.8. The mid-Holocene 'Elm Decline' as a chronological marker of the Early Neolithic.

The following section investigates the chronological relationship between the 'Elm Decline' and the potential evidence for the start of anthropogenic activity during the Mesolithic/Neolithic transition, to assess the degree to which the 'Elm Decline' can be viewed as a proxy chronological marker for the beginning of the Early Neolithic (O'Connell and Molloy 2001; Parker *et al.* 2002). While the previous section and others (Whitehouse *et al.* 2014) has demonstrated the 'Elm Decline' to be an asynchronous 'event' both in time and space, it has continued to be linked with the onset of agriculture (Whitehouse *et al.* 2014, 181).

In order to explore this relationship only pollen profiles outlined in **Section 7.2.1.** which exhibited a considerable and continuous presence of increased representation of *Plantago lanceolata* across the Mesolithic/Neolithic transition were included. Also, in correlation with the methodologies employed in the investigation of the mid-Holocene 'Elm Decline' outlined above, only sites which have either directly dated the start of the *Plantago* curve, or where this could be extrapolated by Bayesian modelling, and the date range for these 'events' was less than 600 years were considered.

A total of eighteen sites were deemed to meet these criteria for the start of a continuous *Plantago lanceolata* curve across the Mesolithic/Neolithic transition (see Table 7.13 & Figure 7.12). The earliest examples is from Clowanstown, CountyMeath (Gearey *et al.* 2010) which has be radiocarbon dated to 4450 – 4330 cal BC (5510±20, *NZA-34453*) and the latest is from Derragh Bog, County Longford (Selby *et al.* 2005; Brown *et al.* 2005), which was dated to *3620 – 3370 cal BC.*

In similarity with date ranges for the 'Elm Decline' the model again indicated a distinct lack of synchroneity for the start of *Plantago* representation across the island. However, it did demonstrate a statistical probability that the start of the *Plantago* curves at Ballynahatty, (Ireland North), Garrynagran and Templevanny Lough (Ireland West) occurred simultaneously (**Group 1**), while it also occurred at Ballyscullion (Ireland North), Ballinphuill, Loughmeenaghan and Lough Dargan (Ireland West) contemporaneously (**Group 2**). The model further demonstrated that the date ranges for the start of the *Plantago* curve was synchronous at Ballynagilly (Ireland North) and Caheraphuca Lough (Ireland West) (**Group 3**), Glenulra Basin and Cooney Lough

(Ireland West) (**Group 4**) and at Derragh Bog (Ireland East), Connemara National Park (Ireland West) and Lackan (Ireland North) (**Group 5**). However, none of these five statistically consistent 'groups' were shown to have been statistically consistent with each other.

Name	BP Date	Calibrated Date/*Posterior Density Estimate* (cal BC)					
		From	to	%	from	to	%
Ireland South							
PDE Lough Cullin	N/A	*4090*	*3880*	*68.2*	*4210*	*3960*	*95.4*
Ireland North							
PDE Fallahogy	N/A	*4040*	*3970*	*68.2*	*4130*	*3940*	*95.4*
PDE Ballyscullion	N/A	*3750*	*3690*	*68.2*	*3790*	*3640*	*95.4*
PDE Ballynagilly	N/A	*3700*	*3500*	*68.2*	*3760*	*3340*	*95.4*
Lackan 1 (UB-800)	4695±50	3622	3375	68.2	3632	3368	95.4
Ireland East							
Clowanstown (NZA-34453)	5510±20	4359	4339	68.2	4444	4330	95.4
PDE Derragh Bog	N/A	*3560*	*3380*	*68.2*	*3620*	*3370*	*95.4*
Ireland West							
PDE Lough Sheeauns	N/A	*4050*	*3840*	*68.2*	*4190*	*3770*	*95.4*
PDE Ballinphuill	N/A	*3830*	*3600*	*68.2*	*3990*	*3510*	*95.4*
PDE Lough Dargan	N/A	*3900*	*3590*	*68.2*	*3970*	*3370*	*95.4*
PDE Garrynagran	N/A	*3940*	*3740*	*68.2*	*3960*	*3660*	*95.4*
PDE Templevanny Lough	N/A	*3890*	*3830*	*68.2*	*3910*	*3700*	*95.4*
PDE Caheraphuca Lough	N/A	*3650*	*3430*	*68.2*	*3850*	*3380*	*95.4*
PDE Glenulra Basin	N/A	*3780*	*3620*	*68.2*	*3850*	*3560*	*95.4*
PDE Connemara National Park	N/A	*3600*	*3300*	*68.2*	*3780*	*3190*	*95.4*
PDE Loughmeenaghan	N/A	*3760*	*3680*	*68.2*	*3780*	*3640*	*95.4*
Cooney Lough (UBA-17008)	4928±32	3713	3655	68.2	3771	3650	95.4

Table 7.13 PDEs/calibrated radiocarbon date ranges for the initiation of a Plantago lanceolata Curve from pollen records across Ireland, where the date range, at 95.4% probability, is less than c.600 years

Despite the overall lack of synchroneity among the date ranges for the start of a continuous representation of *Plantago* across the island, the model does allow for a chronological succession of the palynological signal for potential anthropogenic activity across the Mesolithic/Neolithic transition to be established. As stated above the earliest signal is from Clowanstown, followed by Lough Cullin, Fallahogy and then Lough Sheeauns, which is in turn followed by **Groups 1** to **5** respectively. However, whether this can be said to represent a spatial and temporal spread of Mesolithic/Neolithic transitional anthropogenic activity across the island is uncertain. The number of sites which could be robustly included in the model is unlikely to be sufficient for reliable analyses, while the number of sites from the northern and western region probably represents an additional source of bias within this analysis.

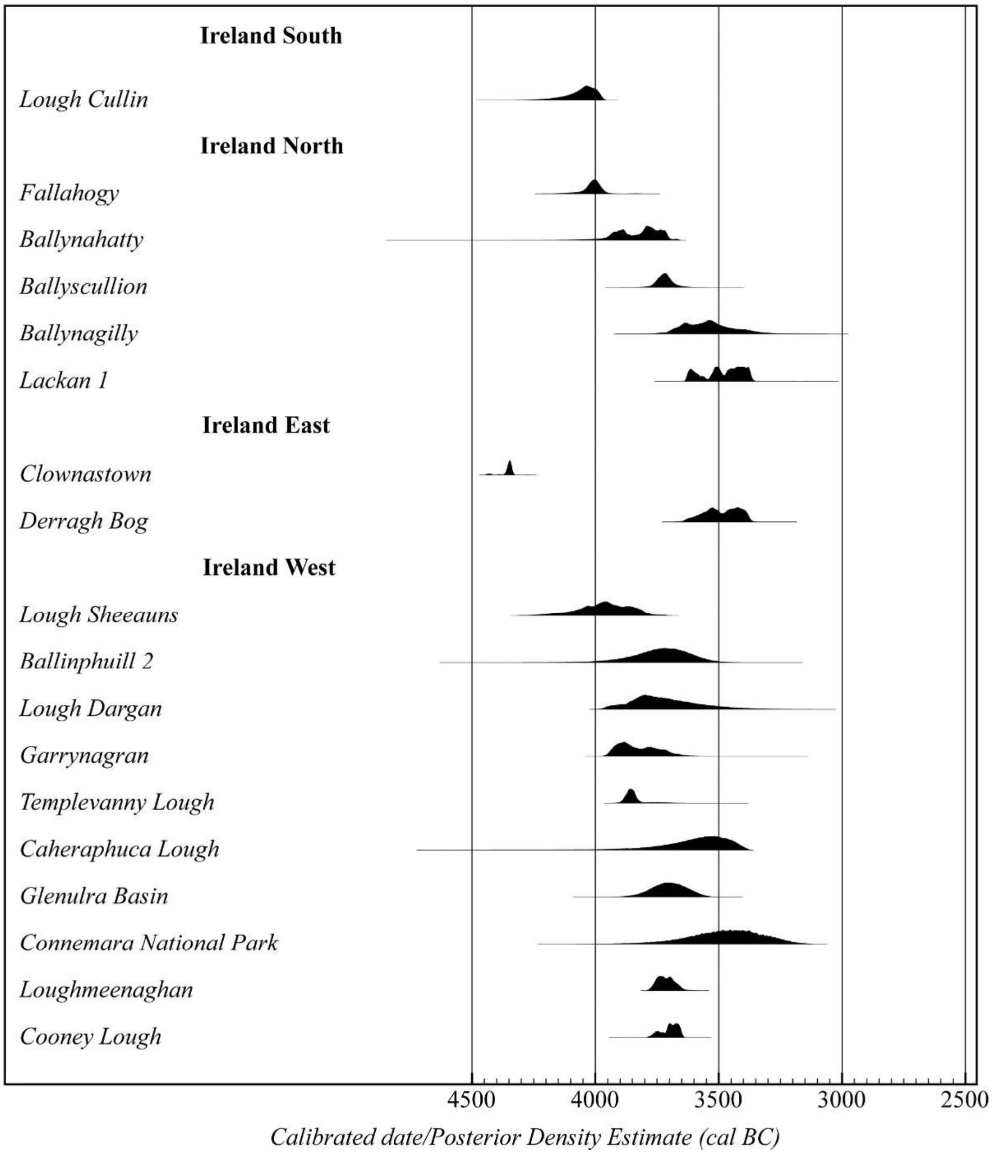

Figure 7.12 Calibrated date/PDE for the initiation of a Plantago lanceolata Curve in Ireland South/North/East/West

The final aspect of the mid-Holocene 'Elm Decline' assessed was to determine the chronological relationship between this 'event' and the start of the *Plantago* curves at each site. At four of the sites included in the model, plus at Arderrawinny, the continuous presence of *Plantago* was demonstrated to have occurred prior to the 'Elm Decline'. Of these, Clowanstown demonstrated a sustained presence of *Plantago* occurred up to *c.*1500 years prior to the 'Elm Decline', although the lack of a mid-Holocene 'Elm Decline' results in this site being unsuitable for the assessment of the relationship of the two ‘events’. A further two sites demonstrate a clear chronological separation between the ‘Elm Decline’ and the start of potential evidence for anthropogenic activity. At both Ballynagilly and Lackan, the date range for the start of the *Plantago* curves is between *170 – 820* and *200 – 570* years respectively, after the ‘Elm Decline’. If the start of the *Plantago* curve at each sites is considered to represent the start of sustained anthropogenic activity, then the model demonstrates that this did not occur at either site for at least two centuries, which would strongly question the temporal correlation between the ‘Elm Decline’ and early agriculture at either site.

Interval between the ‘Elm Decline’ and the start of Plantago Curve at:	*Interval (years)*					
	From	*to*	*%*	*from*	*to*	*%*
Lough Cullin	*0*	*100*	*68.2*	*0*	*220*	*95.4*
Fallahogy	*0*	*20*	*68.2*	*0*	*30*	*95.4*
Ballyscullion	*10*	*50*	*68.2*	*0*	*70*	*95.4*
Ballynagilly	*300*	*320*	*68.2*	*170*	*820*	*95.4*
Lackan	*300*	*510*	*68.2*	*200*	*570*	*95.4*
Clowanstown	*-1340*	*-1440*	*68.2*	*-1260*	*-1480*	*95.4*
Derragh Bog	*0*	*70*	*68.2*	*0*	*160*	*95.4*
Lough Sheeauns	*0*	*-170*	*68.2*	*0*	*-340*	*95.4*
Ballinphuill	*20*	*130*	*68.2*	*0*	*220*	*95.4*
Lough Dargan	*0*	*130*	*68.2*	*0*	*360*	*95.4*
Garrynagran	*30*	*210*	*68.2*	*0*	*370*	*95.4*
Templevanny Lough	*60*	*100*	*68.2*	*10*	*170*	*95.4*
Caheraphuca Lough	*0*	*70*	*68.2*	*0*	*220*	*95.4*
Glenulra Basin	*0*	*-50*	*68.2*	*0*	*-120*	*95.4*
Connemara National Park	*0*	*-140*	*68.2*	*0*	*-310*	*95.4*
Loughmeenaghan	*70*	*170*	*68.2*	*20*	*250*	*95.4*
Cooney Lough	*0*	*220*	*68.2*	*0*	*520*	*95.4*

Table 7.14 Interval between start date for the mid-Holocene ‘Elm Decline’ and the initiation of a Plantago curve (+ indicates before, - indicates after)

The only site which demonstrated a strong connection between the start of potential anthropogenic activity and the ‘Elm Decline’ was at Fallahogy, where the start of the *Plantago* curve occurred between *0 – 30* years after the ‘Elm Decline’. At the remaining eleven sites, the model demonstrated that the start of the *Plantago* curve may have occurred shortly following the ‘Elm Decline’ or possibly up to *c.*500 years after. Therefore, the potential correlation may simply be a result of the inability of the model to accurately reflect the chronological separation between the two ‘events’. At each of these eleven sites, the stratigraphic information of the profile indicates that the ‘Elm Decline’ occurred prior to the initiation of the *Plantago* curve. However, the nature of the calibration radiocarbon/*posterior density estimate* date ranges employed in the model, which despite a clear stratigraphic separation, produced date ranges which overlap, which may have affected the models. While Bayesian analysis can incorporate the stratigraphic information to constrain the resulting models, these can only be achieved at a level where the higher stratigraphic 'event' did not occur prior to the lower 'event'. In essence, because of the resolution and overlapping nature of the calibrated dates/*posterior density estimates,* the stratigraphic information can only constrain the models to the point where the later 'event' is interpreted as occurring after the earlier. For example, in the case of Cooney Lough the model was able to determine that the *Plantago* curve occurred after the 'Elm Decline' but only to the point where it occurred up to *520* years after. Therefore, in this instance it may have occurred within a few years or several hundred years after. It is therefore questionable whether a correlation can be draw between the 'Elm Decline' and the potential start of anthropogenic activity based on the available dataset.

Probability t1 is before t2										
t2	Lough Cullin	Lough Sheeaun s	Fallahogy	Ballynahatt y	Ballinphuill	Lough Dargan	Garrynagran	Cooney Lough	Templevanny Lough	Caheraphuca Lough
t1										
Lough Cullin		76.8	66.45	94.65	97.93	99.90	99.87	100	99.96	98.88
Lough Sheeauns	23.20		31.66	81.18	92.50	93.15	85.83	99.71	85.81	97.46
Fallahogy	33.55	68.34		92.87	97.10	99.56	99.18	100	99.18	98.59
Ballynahatty	5.34	18.81	7.12		75.73	72.85	52.55	93.90	46.09	93.53
Ballinphuill	2.07	7.50	2.89	24.27		50.81	26.50	59.77	19.31	82.83
Lough Dargan	0.09	6.84	0.43	27.15	49.19		28.27	59.57	21.10	75.32
Garrynagran	0.12	14.16	0.81	47.45	73.50	71.72		90.33	46.42	92.27
Cooney Lough	0	0.02	0	6.10	40.23	40.43	9.66		3.77	80.53
Templevanny Lough	0.03	14.18	0.82	53.91	80.68	78.89	53.58	96.23		94.42
Caheraphuca Lough	1.11	2.54	1.40	6.47	17.17	24.68	7.73	19.47	5.58	
Glenulra Basin	0.02	1.46	0.09	12.26	41.45	42.52	14.82	50.78	6.80	81.36
Ballyscullion	0	0.48	0.01	9.73	46.90	44.52	14.32	68.62	5.13	85.93
Connemara National Park (FRK II)	0.16	0.72	0.25	2.69	8.59	14.46	3.37	7.78	2.14	28.14
Loughmeenaghan	0	0.36	0	9.03	45.23	43.33	13.25	63.26	4.64	85.26
Ballynagilly	0.01	0.11	0.01	1.32	14.11	21.90	2.96	5.63	1.12	52.28
Lackan 1	0	0	0	0	2.86	11.18	0.45	0	0.08	24.57
Clowanstown	98.21	100	100	99.23	99.90	100	100	100	100	99.84
Derragh Bog	0	0.01	0	0.003	2.60	11.42	0.44	0.08	0.07	26.19

Table 7.15 Statistical probability of 'event' order for the start of Plantago curves in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary)

Probability t1 is before t2								
t2	Glenulra Basin	Ballyscullion	Connemara National Park (FRK II)	Loughmeenaghan	Ballynagilly	Lackan 1	Clowanstown	Derragh Bog
t1								
Lough Cullin	99.97	100	99.83	100	100	100	1.79	100
Lough Sheeauns	98.54	99.51	99.28	99.64	99.89	100	0.01	100
Fallahogy	99.91	99.99	99.74	100	100	100	0	100
Ballynahatty	87.73	90.26	97.31	90.97	98.67	100	0.77	100
Ballinphuill	58.55	53.10	91.40	54.77	85.89	97.13	0.09	97.39
Lough Dargan	57.48	55.48	85.54	56.67	78.09	88.81	0	88.57
Garrynagran	85.18	85.68	96.63	86.74	97.04	99.55	0	99.55
Cooney Lough	49.22	31.37	92.22	36.74	94.36	100	0	99.92
Templevanny Lough	93.19	94.86	97.86	95.35	98.88	99.91	0	99.92
Caheraphuca Lough	18.64	14.06	71.86	14.73	47.72	75.43	0.16	73.80
Glenulra Basin		41.10	90.71	43.57	85.09	97.99	0	98.41
Ballyscullion	58.90		93.22	53.40	93.32	99.92	0	99.91
Connemara National Park (FRK II)	9.29	6.77		7.12	28.04	46.34	0	44.18
Loughmeenaghan	56.43	46.60	92.87		92.21	99.92	0	99.91
Ballynagilly	14.91	6.68	71.96	7.78		76.64	0	76.09
Lackan 1	2.01	0.08	53.66	0.07	23.35		0	46.28
Clowanstown	100	100	100	100	100	100		100
Derragh Bog	1.59	0.09	55.82	0.09	23.91	53.72	0	

Table 7.16 Statistical probability of 'event' order for the start of Plantago curves in Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary) continued

7.3. The chronology of the Mesolithic/Neolithic transition in southern Ireland.

The following section outlines the chronological of the Mesolithic/Neolithic transition in southern Ireland. The temporal context of palynological 'events', often associated with this transition, is assessed and statistically compared with the chronology of the Early Neolithic archaeological record, which has been outlined in **Chapter 4** and elsewhere (Schulting 2014). The model employed here incorporates not only the palaeoenvironmental analysis of sites undertaken as part of this study but also palaeoenvironmental studies which have previously been undertaken within the study area. Despite an apparent wealth of previous palaeoenvironmental research to draw upon, the number of studies which can be included in this analysis was relatively limited for a variety of different factors, ranging from a lack of a palynological signal for anthropogenic activity during this period to poor chronological resolution in a number of profiles.

The temporal relationship between the mid-Holocene 'Elm Decline' and the start of the Early Neolithic, as defined by the excavated sites in the region, was statistically assessed based on the chronology of this 'event' established at three sites within the region. In addition to the chronology of the 'Elm Decline' from Arderrawinny and Lough Cullin, the date ranges for this 'event' at Knockadoon South (Almgren 2001) and was also incorporated into the model. At Knockadoon South, Almgren (2001, 161) provides a calibrated radiocarbon date range of 4230 – 3710 cal BC (95.4% probability), 4040 – 3800 cal BC (68.2% probability) (5135±65, *Beta-46125*) for the start of the first of four declines in *Ulmus* values.

These three radiocarbon determinations/*posterior density estimates* were statistically assessed to determine the percentage probability of each 'Elm Decline' occurring before, contemporarily or after the *posterior density estimate* date ranges for the start of the Neolithic in southern Ireland (EN Models 1 and 3), as outlined in **Chapter 4.** The *posterior density estimate* date ranges for the start of EN Model 2 was not included due to the poor overall agreement of this model. Also incorporated in the model were the *posterior density estimate* date ranges for the construction and primary use of the portal tomb at Poulnabrone (Schulting 2014, 100) These models were incorporated under the hypothesis that the date range from Poulnabrone may be representative of the broader chronology of portal tomb construction and use.

At all three sites the 'Elm Decline' was statistically more probable to have occurred prior to the start date range for the Early Neolithic derived from EN Model 1 (see Figure 4.40) and EN Model 3 (see Figure 4.44). This would appear to imply that the cause of the 'Elm Decline' in the region was unlikely to relate to Early Neolithic anthropogenic activity. However, the potential for a connection between the 'Elm Decline' and Mesolithic activity, or alternatively archaeologically invisible Neolithic activity cannot be discounted.

The statistical comparison between the date ranges for the 'Elm Decline' and the start of primary use at Poulnabrone (PNB Models 3 – 5) did however provide a potentially more illuminating picture. This comparison is subject to a major caveat as it relies on the assumption that the models for the start of use of Poulnabrone (Schulting 2014, 100) were broadly representative of the start of portal tomb use in the region. A further caution must be inserted here, as large areas of the study region under review are outside the general distribution of this monument type in Ireland. Within the western half of the study area only three confirmed examples of portal tombs are recorded, Arderrawinny and Ahaglisin in County Cork and the excavated, but as of yet unpublished, portal tomb in Killaclohane, County Kerry (Connolly 2015). As two of the three palaeoenvironmental sites discussed here are in the western half of the study region, it is unclear to what extent Neolithic populations engaged in portal tomb construction would have impacted on the natural vegetation at these sites. Also, of these three sites, only Arderrawinny is in close spatial proximity to an example of this monument type, while the sampling site at Lough Cullin is located within a 20km radius of twelve unexcavated portal tombs.

When the date ranges for the 'Elm Decline' at each site was statistically assessed against the start of primary use at Poulnabrone (Schulting 2014) , it was shown to have occurred prior to the potential start date for portal tomb use at Knockadoon South and Lough Cullin. The model therefore suggests that the 'Elm Decline' at these sites was almost certainly unrelated to anthropogenic activity, at least as far as portal tomb construction and use is concerned.

In contrast, an interesting aspect of this analysis is apparent when a statistical comparison is made between the start of use at Poulnabrone and the *posterior density estimate* for the 'Elm Decline' at Arderrawinny. As has been referred to in **Section 2.4.3.1.**, the choice of the sampling site location at Arderrawinny was due to the presence of the Early Neolithic portal tomb *c.*500m to the north-east. The model suggests that start of use from PNB Models 3 and 5 was likely to have occurred contemporaneously with the 'Elm Decline' at Arderrawinny, while the start of use from PNB Model 4 was 60.18% more probable to have occurred after the 'Elm Decline' at Arderrawinny. If the date range for portal tomb construction at Poulnabrone and Arderrawinny were broadly similar, then the model indicates that anthropogenic activity may have been linked in some form to the onset of the mid-Holocene 'Elm Decline' at Arderrawinny.

However, as has been stated throughout this comparison, the model operates under the large caveat that the date range for the use of the portal tomb was similar across the region. The hypothesis that human activity in the form of portal tomb construction and use may be linked to the onset of the mid-Holocene 'Elm Decline' can only be truly examined by obtaining radiocarbon dates for the megalithic structure at Arderrawinny or comparing the radiocarbon record from Poulnabrone with a well dated pollen profile form the Burren.

One further aspect for consideration is the chronological relationship between the *posterior density estimate* for the start of the Neolithic and the palynological signal for woodland clearance and potential anthropogenic activity in the region. When a comparison is made between the chronology of the initiation of both the *Landnam* phase and the *Plantago lanceolata* curve at Lough Cullin and the date range for the start of the Neolithic in the region, the palynological signal for anthropogenic activity appears to be 100% more probable to have occurred prior to the start of occupation at the archaeological sites concerned.

The palynological signal for woodland clearance is therefore not related to the construction and occupation of the Early Neolithic sites incorporated into this study. This is further supported by comparison with the chronology of the peaks in both the *Landnam* phase and *Plantago lanceolata* curve which are again more probable to have occurred prior to onset of the Neolithic as represented by the archaeological record of the region. This would intimate that the Early Neolithic communities represented at the archaeological sites in question were unlikely to have undertaken the woodland clearance exhibited and raises questions as to whether these sites represent the earliest expression of anthropogenic agricultural activity and environmental impact in the region. Indeed, it is difficult to associate the archaeological evidence for the Early Neolithic in the region with the phase of *Landnam* exhibited at Lough Cullin as the model demonstrates this ended prior to the construction and occupation of the Early Neolithic archaeological sites.

The time laspe between the *Landnam* at Lough Cullin and the evidence for Early Neolithic settlement and agriculture expressed in the house and ephemeral sites in the region could possibly suggest that these do not represent the earliest archaeological evidence of Neolithic anthropogenic activity in the region. Earlier archaeological evidence may be represented by the remains of domesticates recovered from Kilgreany Cave (Molleson 1985-6; Woodman *et al.* 1997; Dowd 2002). The date of the redeposited cattle tibia identified at Kilgreany Cave (5190±80, *OxA-4269*) (Molleson 1985-6; Woodman *et al.* 1997; Dowd 2002), being several centuries earlier than the more conclusive archaeological evidence of the 38th century cal BC, presents somewhat of a conundrum in studies of the introduction of Neolithic agriculture in the region. However, when one considers this early date for domesticates in light of the date range for the *Landnam* at Lough Cullin, one must surely question whether this (and other domesticates) represent outliers or some pre-cereal cultivation, house 'horizon' selective adoption of Neolithic practices.

Indeed, when the date for the cattle bone from Kilgreany was assessed for its statistical relationship with the *Landnam* at Lough Cullin an interesting picture emerges. The model indicates that the initiation of both the *Landnam* phase and the *Plantago lanceolata* curve at Lough Cullin are statistically more probable to have occurred prior to the date range for the cattle bone from Kilgreany Cave (see Table 7.17). The Kilgreany Cave domesticate was however, 86.32% more probable to have occurred before the peaks in both the *Landnam* phase and *Plantago lanceolata* curve at Lough Cullin. This could possibly indicate that if the date for the cattle bone from Kilgreany Cave is correct and represents the presence of domesticates in the region at this time, then the woodland clearance and palynological evidence for open habitats near Lough Cullin may be as a result of some pre-'house horizon' and cereal cultivation Neolithic in the region. This issue will be returned to in more detail later.

The relationship between the post-*Landnam* signal for anthropogenic activity and Early Neolithic agriculture is further supported with the comparison of the *posterior density estimate* date ranges for cereal cultivation and the archaeological record. The model indicates that the potential evidence for cereal cultivation recorded in PAZ LC5c is more probable to have occurred after the start of the Early Neolithic in the region and 81.48% more probable to have occurred after the start of cereal cultivation in the region as defined by the model in Figure 4.36. The model also demonstrated that the *Cerealia*-

type pollen recorded in PAZ LC5c was 99.76% (EN Model 1) and 86.68% (EN Model 3) more probable to have occurred prior to the end of the Early Neolithic.

This would imply that the arable activity indicated in the pollen record is chronologically consistent with the archaeological evidence for cereal cultivation exhibited in the broader Early Neolithic landscape. However, the earliest palynological signal for cereal cultivation, recorded in PAZ LC5b was shown to be 93.53% (EN Model 1) and 99.75% (EN Model 3) more probable to have occurred prior to the onset of the Early Neolithic as expressed in the archaeological record. This would have significant implications for the timing of the start of arable activity in the region, especially considering the lack of archaeological evidence for cereal cultivation in the region prior to *3750 – 3690 cal BC* (see **Section 4.4.7.)** or indeed across the island (cf. McClatchie *et al.* 2014) before *c.*3750 cal BC.

The statistical comparison of the *posterior density estimate* date ranges for the archaeological record of the southern Ireland and the palynological 'events' at Lough Cullin provide an illuminating picture of the start of the Neolithic in the region. While the palynological signal for arable activity in PAZ LC5c and the later part of the *Plantago lanceolata* curve can almost certainly be said to represent evidence for a similar Early Neolithic community as those expressed in the archaeological record, the chronology of the earlier clearance phase and *Cerealia*-type pollen would seriously question whether these 'events' could be said to relate to the same Neolithic populations. The model infers that the initial clearance phase at Lough Cullin was highly unlikely to result from the Early Neolithic communities so far identified in the archaeological record and raises questions as to whether these are the earlier expression of Neolithic practices in the region. The statistical comparison with the early cattle bone from Kilgreany Cave does certainly propose the hypothesis that this part of the palynological record may relate to the activities of early pastoralists, who are otherwise largely invisible in the archaeological record.

However, the lack of further similarly well-defined and dated clearance episodes in the region does not allow for a robust comparison to be made. At Arderrawinny, as has been emphasised on several occasions, the palynological signal for Early Neolithic anthropogenic activity is less conclusive and more problematic to decipher. The model utilised here, again expresses the suggestion that a degree of vegetation openness had commenced at Arderrawinny several centuries prior to the *posterior density estimate* for the start of the Neolithic in southern Ireland (see Table 7.17).

Despite this lack of clarity on the exact nature of anthropogenic activity in the region, the unexcavated portal tomb does provide evidence for an Early Neolithic presence in the region. If a similar construction date for the portal tombs at Poulnabrone and Arderrawinny is assumed, then the model suggests that woodland openness, signified by the initiation of a continuous presence of *Plantago lanceolata,* almost certainly occurred before the construction of the portal tomb. This would suggest that the portal tomb at Arderrawinny was constructed in an already open landscape. An additional caveat must be placed on this analysis as the long tail on the *posterior density estimate* for the initiation of the *Plantago* curve could be said to have possibly skewed the results presented here. However, this suggestion is strongly supported as the pre-'Elm Decline' peak in *Plantago* values was also suggested to be 74.71% (PNB Model 3), 87.38% (PNB Model 4) and 73.92% (PNB Model 5) more probable to have occurred prior to portal tomb construction. Therefore, if the construction and primary use phase at Poulnabrone is found to be representative of general portal tomb construction across the region, the initial openings in vegetation in PAZ ARD3 was unrelated to the construction and use of the portal tomb.

However, as referred to above a second peak in *Plantago lanceolata* percentage values was recorded several spectra after the mid-Holocene 'Elm Decline' at *3810 – 3520 cal BC.* The model demonstrated that this post-'Elm Decline' increase in *Plantago lanceolata* was 95.58% (Poulnabrone Model 3), 92.19% (Poulnabrone Model 4) and 95.64% (Poulnabrone Model 5) statistically more probable to have occurred after the *posterior density estimate* for start of use at Poulnabrone. This may indicate the increased levels of vegetation openness in PAZ ARD5 resulted from anthropogenic activity related to the tomb at Arderrawinny. Increased vegetation openness related to Early Neolithic activity is further suggested by the statistical comparison of this peak in *Plantago lanceolata* and the *posterior density estimate* date ranges for the start and end of Early Neolithic activity as defined by EN Models 1 and 3. The model indicates that the start of Neolithic activity in the region was 81.95% (EN Model 1) and 77.24% (EN Model 3) more probable to have occurred prior to this increase in *Plantago lanceolata*, which may intimate that this increase may relate to Early Neolithic activity near the sampling site.

The overall model therefore indicates that the creation of open environments at Arderrawinny was unrelated to Early Neolithic anthropogenic activity at least as far as expressed in the archaeological record, with the initiation of the *Plantago lanceolata* curve occurring before the start of the Early Neolithic or construction of the portal tomb. However, the model does intimate a potential causal link between the construction of the portal tomb and the onset of the 'Elm Decline' at the site. This in addition to the increase in *Plantago lanceolata* representation after the start of the Early Neolithic in southern Ireland may be said to provide evidence for an Early Neolithic presence in the vicinity of the sampling site.

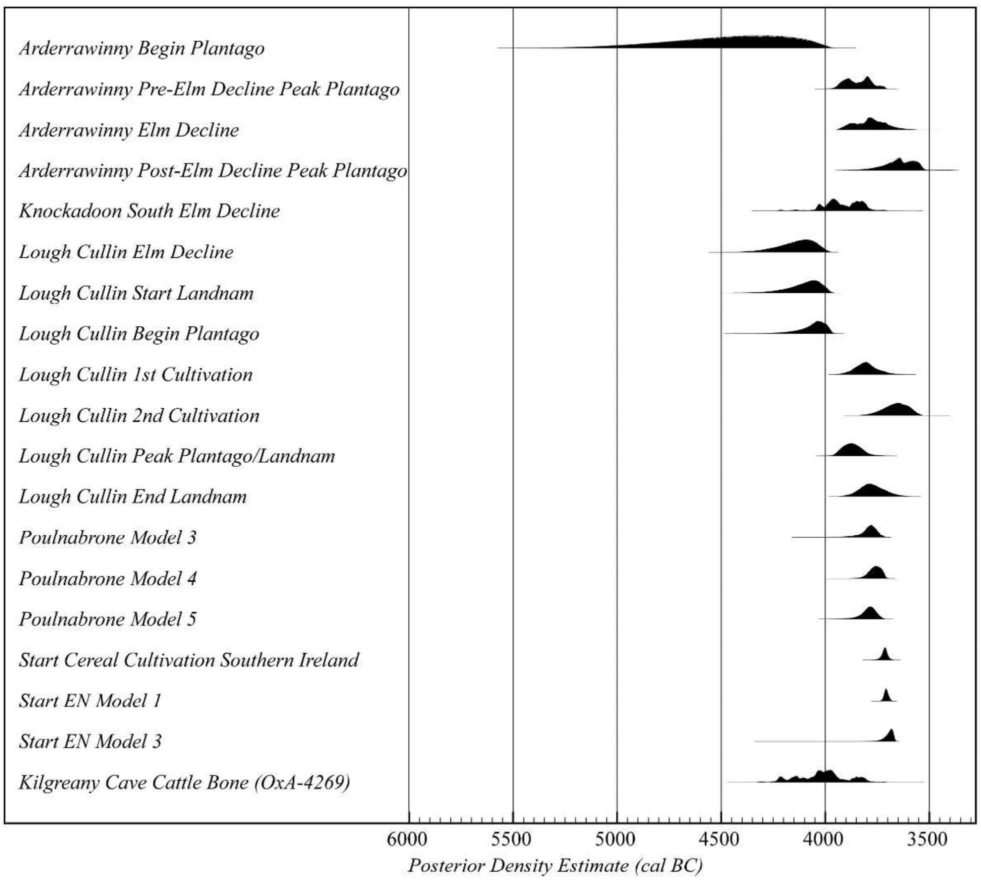

Figure 7.13 Posterior Density Estimate/Calibrated dates for the start of Neolithic practices and associated palynological 'events' in southern Ireland

7.4. Conclusions.

The results of this study of the chronology of the mid-Holocene 'Elm Decline' in Ireland indicated that it was a chronologically asynchronous 'event'. This analysis also failed to establish whether a pattern for this 'event' can be elucidated on a spatial scale *contra* Whitehouse *et al.* (2014, 196), who suggest '*earlier start to the Elm Decline in the north of Ireland compared with the west*'. While certain sites within a particular region demonstrated a degree of synchroneity, these were generally in the minority of sites in that particular region. Also, in many cases, these synchronous groups contained sites which were outside that specific region, which would cast doubts as to whether a regional spatial pattern could be determined for the mid-Holocene 'Elm Decline'.

The results of this analysis also failed to establish whether a pattern for the 'Elm Decline' could be elucidated based on topographical parameters as no robust pattern could be observed when sites were assessed based on altitude. The reliability of the 'Elm Decline' as a chronological proxy for the start of anthropogenic activity across the Mesolithic/Neolithic transition was also questioned in this research. While many sites demonstrated that the anthropogenic activity may have occurred shortly after the 'Elm Decline', this may have also occurred up to five centuries later in some instances. It is therefore uncertain whether such activity contributed to the cause of the 'Elm Decline' and how reliable it is as a chronological proxy for the start of the Neolithic in Ireland.

Furthermore, this chapter has outlined the results of the integrated Bayesian analysis of the archaeological dataset and the palaeoenvironmental evidence for the 'events' often associated with the Mesolithic/Neolithic transition in Ireland. This model has shown no chronological connection between the Early Neolithic archaeology of the region and the onset of the mid-Holocene 'Elm Decline'. However, a potential correlation between the 'Elm Decline' at Arderrawinny and the construction and use of the nearby portal tomb was suggested. This analysis has also raised pertinent questions about the nature of the earliest woodland clearance in the region, the *Landnam* phase at Lough Cullin was shown to have occurred prior to the start of the Early Neolithic archaeological record in the region. The model did tentatively suggest a potential connection between this woodland clearance and the presence of pre-'Neolithic' domesticates in the region.

The model demonstrated that the post-*Landnam* phase of woodland openness and later potential cereal cultivation was probably related to the Early Neolithic activity. Questions still remain regarding the earliest evidence of arable activity however, as despite strong indications in the palynological and loss on ignition data that this represented cereal cultivation, this was shown to have occurred prior to the start of the Neolithic, as expressed in the archaeological record. This may have considerable implications on our understanding of how and when the Neolithic began in the region and will be discussed in **Chapter 8**.

The evidence from Arderrawinny was less conclusive however, as the model indicated that the open environments occurred prior to the start of the Neolithic or indeed the hypothesised date for the construction of the portal tomb. The model did suggest that the post-'Elm Decline' increases in open environments occurred after the start of Neolithic practices in the region and may relate to Early Neolithic anthropogenic activity.

Probability t1 is before t2						
t2	Start EN Model 1	Start EN Model 3	Start Poulnabrone Model 3	Start Poulnabrone Model 4	Start Poulnabrone Model 5	Kilgreany Cave Cattle Bone
t1						
Arderrawinny Begin Plantago Curve	100	100	99.99	100	100	95.49
Arderrawinny Elm Decline	84.05	86.26	46.16	60.20	44.65	4.08
Arderrawinny Peak Plantago Curve	99.51	98.79	74.71	87.38	73.92	9.95
Arderrawinny Post-Elm Decline Peak Plantago Curve	18.05	22.76	4.62	7.81	4.36	0.37
Knockadoon South Elm Decline	99.77	99.60	91.40	96.88	31.24	25.53
Lough Cullin Elm Decline	100	100	99.95	100	100	80.75
Lough Cullin Begin Landnam	100	100	99.91	100	99.99	73.65
Lough Cullin Begin Plantago Curve	100	100	99.83	100	99.98	64.82
Lough Cullin Peak Landnam	95.43	99.67	89.54	96.90	89.68	13.68
Lough Cullin Peak Plantago Curve	100	99.67	89.54	96.90	89.68	13.68
Lough Cullin End Landnam	87.05	88.50	42.20	59.11	40.55	3.16
Lough Cullin First Cereal Cultivation	95.43	95.44	59.79	76.47	58.29	5.29
Lough Cullin Second Cereal Cultivation	21.81	27.72	3.40	7.06	3.11	0.18

Table 7.17 Statistical probability of 'event' order for the palynological events and the start of Early Neolithic activity in southern Ireland, calculated using Order() command in OxCal. (c.50% indicates 'events' were contemporary)

Chapter 8 - Discussion and synthesis

8.1. Introduction

The following chapter synthesises and discusses the results of this research which have been outlined in **Chapters 4-7**. Firstly, the results of the palaeoenvironmental analysis from Lough Cullin, outlined and discussed in **Chapter 5**, and Arderrawinny, outlined and discussed in **Chapter 6**, are synthesised and compared to outline the principal findings, similarities and differences between the two sites. While the results from each site were outlined, and the implications of these analyses on the understanding of the ecological development of the local landscape was discussed in the relevant chapters, **Section 8.2.** delivers a concise comparison between the sites to provide a broader understanding of this development across the region. The implications of these analyses on the understanding of various aspects of Mesolithic/Neolithic transition are considered in **Sections 8.3.** to **8.5.**

The results of the Bayesian analysis of the mid-Holocene 'Elm Decline', outlined in **Section 7.2.** are discussed in **Section 8.3.** below. The temporal and spatial cohesiveness of this 'event', or lack thereof, in addition to its association with anthropogenic activity is considered and discussed. The temporal relationship between the evidence for anthropogenic activity across the Mesolithic/Neolithic transition, which was outlined in **Chapters 4** and **7**, and its implications on our understanding of the process of Neolithisation is discussed in **Section 8.4.**, while the palaeoenvironment of portal tombs is considered in **Section 8.5.**

8.2. History of woodland development in southern Ireland

The following section summaries, discusses and compares the principal features of the two palaeoenvironmental assessments conducted as part of this research (for a detailed discussion see **Chapters 5** and **6**). The two sampling sites contrast considerably in terms of their geological, topographical and local edaphic environments. The lake site Lough Cullin is located in the east of the study region while, Arderrawinny, located in the western half of the region, is from a small mire located beside a small lake at the junction between the hillslopes and valley floor. Both are relatively small sampling sites with Lough Cullin having a radius of *c.*100m and Arderrawinny a radius of *c.*60m, As such these are expected to accurately reflect local vegetation and land use dynamics within a *c*.400 – 500m and *c*.300 – 400m radius, respectively, based on the site radii simulations of Sugita (1994).

Lough Cullin is at an elevation of approximately 20mOD and is overlain on Tournaisian Limestone. The principal soil type of the region consists of mineral rich brown earths and the surrounding landscape is heavily utilised for pastoral agriculture, while a growth of planted silver birch (*Betula pendula*) trees is located to the east of the lake. The sampling site at Arderrawinny is also at an elevation of approximately 20mOD, but is overlain on Devonian Old Red Sandstone, while the primary soil type of the region is peaty podzols. A large ridge of exposed bedrock, covering *c.*180 hectares runs to the west of the site, while a similar ridge also runs to the immediate south. The present landscape consists of low scrub woodland to the east of the site, while an area of grazed pasture lies to the immediate north of the site, between it and the portal tomb.

The two sampling sites also represented varying degrees of archaeological visibility (see **Section 2.4.3.**). A solitary Early Neolithic portal tomb, two excavated Bronze Age wedge tombs (O'Brien 1999) and an unclassified cairn represent the principal extant archaeological remains in the vicinity of Arderrawinny. In contrast, Lough Cullin is located within a relatively rich Mesolithic/Neolithic archaeological landscape, with excavated examples of houses, ephemeral sites, seventeen unexcavated Portal tombs and one excavated court tomb within a 20km radius of the lake. The cave burial site at Kilgreany, with its enigmatic early cattle bone, is also located in the south-eastern part of the study region. The main focus of these palaeoenvironmental investigations was to reconstruct vegetation dynamics and anthropogenic impact during the Mesolithic/Neolithic transition. These and other findings of importance from the research are now discussed.

Early Holocene

Both pollen profiles extended form the Early Mesolithic, Lough Cullin from *8610 – 8000 cal BC* and Arderrawinny from *8870 – 7210 cal BC*, until the Late Neolithic (LC) and the Late Bronze Age/Iron Age (ARD). During the Early Mesolithic the vegetation at Lough Cullin consisted of a dense oak-elm broadleaf woodland, with hazel growing as an understorey scrub, while the at Arderrawinny the local landscape was dominated by hazel scrub woodland with birch, oak and elm probably growing in scattered distribution further to the north and east of the sampling site. Pine was unlikely to have been a major component of either landscape (cf. Pilcher *et al.* 1995; Lageard *et al.* 1999; Lisitsyna *et al.* 2011) during this period, while alder had yet to become established (cf. Lisitsyna *et al.* 2011; Douda *et al.* 2014) in the region.

The absence of pine from the local landscape at Lough Cullin is reflected in other profiles from the east and midlands (e.g. Caseldine and Hatton 1996; Selby *et al.* 2005), although pine was to have been a significant woodland component at Kelly's Lough (Leira *et al.* 2007). The presence of its pollen at Lough Cullin was, therefore, probably representative of long-distance transport from a similar such source in the region. In contrast pine appeared to have become a significant woodland component in the south-west from *c.*9500 cal BP (Mitchell 2006, 253; 2008, 74), becoming abundant at Arderrawinny from *7080 – 6820 cal BC*, and at a similar timeframe across the south-west (Lynch 1981; Mitchell 1989; Mitchell and Cooney 2004).

Evidence for open habitats within the deciduous woodland at Lough Cullin was restricted and probably limited to areas of wet grassland close to the lake edge, while at Arderrawinny the high values of non-arboreal pollen would intimate possible areas of wet grassland close to the lake edge, while areas of dry acidic grassland were present on the peaty podzol soils to the immediate north of the site. The degree of vegetation openness at Arderrawinny in this period was unusual in the context of pre-'Elm Decline' woodlands in Ireland, although a similar ecological composition was evidenced at Caherkine Lough, County Clare (O'Connell *et al.* 2001) and Lough Mór on Inis Oírr (Molloy and O'Connell 2004). The cause of these openings may relate to Mesolithic activity as has been suggested elsewhere (e.g. Simmons and Innes 1996; Innes and Blackford 2003; Smith 2011; Warren *et al.* 2014), but it is more probable that the local edaphic conditions and ridge of exposed bedrock to the south and west of the site restricted the development of a dense broadleaf canopy.

8.2kyr event

Possible woodland responses to climatic anomalies associated with the 8.2kyr BP event (cf. Ghilardi and O'Connell 2012) was suggested at Lough Cullin between *7030 – 6130 cal BC* and *6370 – 6010 cal BC,* where a decrease in hazel and oak and a corresponding increase in pine and birch was recorded. The abrupt reduction in hazel and oak may have resulted from climatic deterioration as both respond rapidly to environmental change (cf. Atkinson 1992; Richardson and Rundel 1998; Tallantire 2002; Giesecke *et al.* 2008; Paus 2010), and it was therefore assumed that these are reflecting climate, especially thermal, anomalies. This reduction in thermophilus taxa and an increase in cool-tolerant trees is also exhibited elsewhere on the island (e.g. Huang 2002; Molloy and O'Connell 2004; O'Connell and Molloy 2005; Ghilardi and O'Connell 2012), may also represent an expression of the 8.2kyr event.

This climate anomaly could possibly correlate with the anomalies recorded in the Greenland ice-core records (Rasmussen *et al.* 2007; Thomas *et al.* 2007), which may have resulted from changes in the strength of the Atlantic meridional overturning circulation (AMOC) (cf. Alley *et al.* 1997; Alley and Ágústsdóttir 2005; Ellison *et al.* 2006; Hede *et al.* 2010) and resulted in colder and dry conditions in the North Atlantic region (Alley *et al.* 1997; Barber *et al.* 1999; Alley and Ágústsdóttir 2005; Wiersma and Renssen 2006).

A similar palynological signal was also noted at Arderrawinny, although this appeared to have occurred several centuries earlier than at Lough Cullin, at *7080 – 6820 cal BC.* The fluctuations in hazel, oak and pine values at Arderrawinny were similar to a fluctuations of the same taxa at Lough Cullin, however, this 'event' appeared to lie outside the accepted date range for climate deterioration around the time of the 8.2kyr BP event (Risebrobakken *et al.* 2003; Rohling and Pälike 2005). This could possible indicate an earlier phase of climatic or environmental deterioration, which was evidenced in the south-west, as a similar fluctuation in hazel values is recorded at Ballinloghig Lake from *c.*9,700 BP (Barnosky 1988, 33) and also at Lough Adoon Valley (Dodson 1990).

Pre-'Elm Decline'

By the Late Mesolithic pine had probably become a component of the local woodland canopy at both sites, although to a far more substantial degree at Arderrawinny. At Arderrawinny the establishment of pine altered the local woodland canopy, with the vegetation dynamic becoming more comparable to a mixed broadleaved/conifer woodland. The expansion of pine would have resulted in reductions in the hazel dominated scrub, which was presumably shaded by these tall canopy trees. However, the pine dominated woodland was unlikely to have covered the entire basin as open habitats persisted, probably again in the immediate vicinity of the lake. The mixed broadleaved/conifer woodland was therefore likely to represent extra-local growth, possibly up to *c.*500m away from the lake with the immediate *c.*50m around the lake consisting of an open grassland environment.

In contrast at Lough Cullin, the pine populations did not substantially alter the ecological composition of the local woodland, which continued to be an oak-elm dominated broadleaf woodland. Pine was probably confined to the poorer mineral soils near the lake. The presence of local pine populations was short lived however, as alder expanded rapidly to replace pine, presumably on the poorer soils near the lake edge. The establishment of alder at Lough Cullin, which presumably led to the formation of alder carr-woodland at the lake edge, marked the Boreal/Atlantic transition (Jessen 1949; Mitchell 1951). In similarity with other sites in the region (e.g. Caseldine and Hatton 1996; Timpany 2009; Gearey *et al.* 2010), the pre-'Elm Decline' landscape therefore consisted of a mixed elm-oak-hazel woodland growing on the drier mineral soils and an alder carr woodland near the lake.

However, at Arderrawinny this expansion was unusually absent, especially considering the sampling site location. While alder is deemed to have had become established within the woodland canopy across much of Ireland between 7000 and 6000 BP (Birks 1989), a much later date for its expansion in the south-west has been evidenced (e.g. Lynch 1981; Barnosky 1988; Mitchell 1989; Mighall and Lageard 1999; Mighall *et al.* 2004; 2008). The general absence of spatial coherence of the alder expansion within Britain and Ireland appears to be very specific in comparison to the generally observed 'stepping stone' nature of expansion for other arboreal taxa (Bennett and Birks 1990). This delayed alder expansion in the region possibly resulted from environmental constraints rather than the effect of slow colonisation and may account for the unusual absence of alder at Arderrawinny at this time.

Prior to the Mesolithic/Neolithic transition the vegetation dynamic at Lough Cullin would have differed between the immediate environs of the lake edge (*c.*50 – 100m) and the broader catchment area of the sampling basin (*c.*100 – 600m). The lake was likely to have been fringed by an alder-willow carr woodland and small areas of open wet grassland, while a rather closed oak-elm-hazel broadleaf woodland dominated on the drier mineral-rich soils. At Arderrawinny the landscape was still dominated by mixed broadleaved/conifer woodland, although with a less dense canopy. This was evidenced by the expansion of shade intolerant taxa such as hazel and holly, while the continuous presence ribwort plantain and other light-demanding herbaceous taxa pointed to an expansion of grassland on the mineral-rich or peaty podzol soils to the immediate north of the sampling site.

The expansion and continuous presence of ribwort plantain recorded at Arderawinny prior to the mid-Holocene 'Elm Decline' was unusual in Irish pollen diagrams and so its continuous, if low, representation in the pollen record inferred a degree of openness that was unexpected in the closed woodland environment in such contexts. However, a number of pollen diagrams, notably Clowanstown (Gearey *et al.* 2010), An Lough Mór (Molloy and O'Connell 2004) and Lough Sheeauns (Molloy and O'Connell 1991) demonstrate a similar degree of pre-'Elm Decline' openness. However, whether this relates to anthropogenic activity or the terrestrial environment is less certain, as only at Clowanstown (Mossop and Mossop 2009) was direct archaeological evidence for Mesolithic activity provided. This is not to say that a lack of archaeological evidence equates to a lack of a Mesolithic presence at Arderrawinny, especially considering the ephemeral nature of Late Mesolithic society. However, given the nature of the local edaphic environment, the degree and duration of woodland openness at Arderrawinny was probably influenced by the edaphic environment of the area rather than anthropogenic activity.

'Elm Decline'

A reduction in elm was exhibited in both profile during the Mesolithic/Neolithic transition (*c.*4500 – 3750 cal BC) which was suggested to represent the mid-Holocene 'Elm Decline' in the region. However, due to the nature of the Late Mesolithic woodland at both sites this was exhibited in more pronounced detail at Lough Cullin than at Arderrawinny. The chronology of this 'event' at both sites further supports the asynchronous nature of the 'Elm Decline' in Ireland (See **Chapter 7**, also Parker *et al.* 2002; Whitehouse *et al.* 2014), occurring at Lough Cullin from *4320 – 3990 cal BC*, and from *3890 – 3700 cal BC* at Arderrawinny (see below).

The 'Elm Decline' at Lough Cullin was concomitant with overall reductions in the deciduous woodland, with a decrease in oak and hazel and evidence for the presence of increased meadow-like environments. These open habitats were confined to the mineral-rich soils as the alder-willow woodland carr fringing the lake appeared to be unaffected. This evidence for open habitats was recorded from *4210 – 3960 cal BC*, *0 – 220* years after the 'Elm Decline' and indicated that human impact commenced at Lough Cullin considerably earlier than the suggested date for the introduction of Neolithic houses and cereal cultivation in Ireland (See below, also **Chapter 4**; McSparron 2008; Cooney *et al.* 2011; McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Evidence for woodland instability and/or early agricultural activity in post-'Elm Decline' contexts is also exhibited in other profiles across the island (e.g. Mitchell 1942; O'Connell *et al.* 1988; Molloy and O'Connell 1991; Brown *et al.* 2005; Selby *et al.* 2005; Caseldine and Fyfe 2006; Ghilardi and O'Connell 2013; Molloy *et al.* 2014), which has resulted in the perceived correlation between this 'event' and Neolithic anthropogenic activity (Whitehouse *et al.* 2014, see below).

An increase in holly was also apparent at this time, in similarity with Kilmaddy Lough (Hirons and Edwards 1986), Lough Catherine (Hirons and Edwards 1986), Lough Sheeauns (Molloy and O'Connell 1987; 1991) and Lough Namackanbeg (O'Connell *et al.* 1988) and may indicate soil erosion in correlation with suspected woodland disturbance. Further supporting evidence for woodland reduction can be inferred from the loss on ignition dataset, which exhibits increased minerogenic in-wash into Lough Cullin, suggesting increased soil erosion locally immediately following the 'Elm Decline'. The identification of cereal-type pollen at *3950 – 3670 cal BC* and again from *3830 – 3530 cal BC* indicated that arable farming had commenced in the vicinity of Lough Cullin while the presence of ribwort plantain, daisies, docks and buttercups inferred the presence herbaceous grassland, with the degree of taxonomic biodiversity indicating pastoral agriculture was also being practiced in the centuries follow the 'Elm Decline'.

The *Landnam* phase at Lough Cullin demonstrated its greatest intensity until *3890 – 3650 cal BC*, indicating a potential woodland clearance phase of between *140 – 530* years. Non-arboreal pollen taxa continue to rise and the presence of light demanding non-arboreal taxa such as ribwort plantain, buttercups, docks, daisies, mugwort and nettles would strongly indicate open environments around Lough Cullin. The pollen percentage diagram would indicate the clearances mainly involved oak, with hazel effected to a lesser degree.

At Arderrawinny in contrast the 'Elm Decline' did not appear to initially represent a further reduction in the broadleaf/conifer woodland, as pine expanded and open habitats were reduced. Although significant decreases in elm were exhibited in certain diagrams from elsewhere (e.g. Pilcher and Smith 1979; O'Connell 1980; Hirons and Edwards 1986; see also O'Connell and Molloy 2001; Parker *et al.* 2002; Whitehouse *et al.* 2014), low elm values characterise pollen diagrams from south-west Ireland, often resulting in difficulties identifying the mid-Holocene 'Elm Decline'. This is particularly apparent on the Mizen peninsula, where elm was a minor woodland component (Mighall and Lageard 1999; Mighall *et al.* 2004; 2008).

The immediate aftermath of the 'Elm Decline' at Arderrawinny was characterised with an expansion of the woodland canopy, especially increased representation of pine. Reductions in the woodland canopy and an expansion of grassland was, however, evidenced form *3720 – 3510 cal BC*, *30 – 350* years after the 'Elm Decline'. This could have possibly related to anthropogenic activity in the sampling site basin in association with the nearby Portal tomb. Although, as this represented further increased open habitats in an already relatively open landscape, this interpretation may be inconclusive (see below).

Post 'Elm Decline'

From *3890 – 3650 cal BC* there was a distinct recovery in oak and ash at Lough Cullin, although elm did not fully recover until later. However, the continued presence of light demanding taxa such as ribwort plantain would continue to suggest the presence of open environments around Lough Cullin. The profile provided evidence for the continuity of open environments for *360 – 670* years, after which woodland regeneration occurred and a decline in anthropogenic indicators became apparent from *3640 – 3480 cal BC.* The local vegetation record was again dominated by a relatively closed oak-elm-ash broadleaf woodland, while an alder-willow woodland carr surrounded the lake. Open environments probably consisted of areas of wet grassland at the edge of the sampling site, while the limited areas of dry meadow-like environments and possibly grazed swards existed on the drier mineral soils.

At Arderrawinny a phase of woodland regeneration occurred from *3640 – 3200 cal BC*, where a denser pine dominated canopy developed. Ribwort plantain, which had been recorded continuously since the Late Mesolithic ended at *3540 – 3070 cal BC* and evidence for open environments were at their lowest for the entire profile. A similar pattern of re-afforestation and abandonment is noted during the Middle Neolithic in other parts of Ireland (e.g. Pilcher and Smith; O'Connell 1980; Molloy and O'Connell 1991; 1995a; 2004; Caseldine and Hatton 1996; O'Connell and Molloy 2001; Ghilardi and O'Connell 2013; Molloy *et al.* 2014) and draws comparisons with the traditional *Landnam* clearance models (O'Connell and Molloy 2001).

At Lough Cullin a further decrease in elm is once again exhibited at *3390 – 3110 cal BC,* mirroring examples from elsewhere in the region, (Caseldine and Hatton 1996; Gearey *et al.* 2010). This reduction in elm at Lough Cullin is primarily concomitant with increased representations of alder, a slight increase in ash and marginally increased levels of non-arboreal taxa. However, while there is a marginal increase in non-arboreal pollen percentage following this second reduction in elm it is primarily attributable to increase wet-loving taxa such as sedges and meadowsweet suggesting a possible expansion of open areas adjacent to the lake edge rather than increased open dryland habitats driven by anthropogenic activity. At Arderrawinny elm had failed to recover after the 'Elm Decline' and therefore no such reduction was evident.

From *3040 – 2530 cal BC* at Lough Cullin a second phase of woodland reduction is evidenced, in contrast to other profiles from the region (e.g. Heery 1997; Connolly 1999; O'Connell and Molloy 2001; Stefanini 2008). Thereafter increased evidence of open environments were exhibited at the expense of primarily hazel and oak. The presence of herbaceous taxa, indicative of meadow-like grasslands, would suggest an increase in open habitats on the drier mineral soils near the lake. The presence of cereal-type pollen and ruderal taxa, possibly indicative of arable activity, would suggest that farming, both pastoral and arable, was once again being practised in openings within the broadleaf woodland. The potential reappearance of agricultural activity in the region during the Late Neolithic is also hinted at from Clowanstown (Gearey *et al.* 2010) and from other sites across the island (e.g. Pilcher and Smith 1979; Fossitt 1994; Molloy and O'Connell 2004).

At Arderrawinny during the Chalcolithic to Early Bronze Age a potential shift in hydrological conditions and a return of open habitats was evidenced. Reduction in the broadleaf/conifer woodland occurred, as pine began to decline from *2870 – 2470 cal BC and* likely marked the beginnings of the 'Pine Decline' in the region (see **Section 6.7.1.**). Numerous competing hypotheses have been proposed for the cause of this reduction in pine including anthropogenic activity (Dodson 1990), the spread of blanket peat and changing hydrological conditions (Bradshaw and Browne 1987). Increased sedge and wetland herbaceous taxa appears to indicate an expansion of wet grassland in the immediate environs of the lake edge. This expansion of wet-loving taxa is also indicated across the wider south-west region at this time (Barnosky 1988; Dodson 1990; Mighall and Lageard 1999), while Monk (1993) notes that the spread of blanket peat commenced across the region at this time. Hazel representation increased considerable which would intimate a return to scrub woodland in the extra-local landscape of the sampling basin or alternatively increased pollen productivity due to the reduction of the pine canopy, while increased heather in the Middle to Late Bronze Age indicates the development of dry siliceous heath.

By the Late Bronze Age to Iron Age, alder was likely to have become a minor component of the local landscape and with increased willow representation may indicate the development of patches of wet alder-willow carr woodland at the edge of the lake. Herbaceous taxa also increased at this time and with the continuous presence of ribwort plantain, clover and other ruderal taxa may indicate the presence of meadow-like grasslands or grazed swards, which indicates the presence of Bronze Age farming communities in the sampling basin. A similar signal for Bronze Age farming was also noted at Cadogan's Bog (Mighall and Lageard 1999), indicating that agricultural was being practiced across the Mizen peninsula at this time.

These two palaeoenvironmental studies demonstrate a varied composition of woodland taxa for much of the early Holocene between the east and west of the study region, with a mixed deciduous woodland at Lough Cullin and initially a hazel dominated scrub woodland, followed by a conifer woodland as the principal ecological component of the local landscape at Arderrawinny. The woodland remained relatively closed at Lough Cullin until after the mid-Holocene 'Elm Decline', whereas a considerable degree of openness was exhibited at Arderrawinny, probably resulting from the local environmental and edaphic conditions.

Following the mid-Holocene 'Elm Decline' a *Landnam* phase was exhibited at Lough Cullin, with this intense phase of woodland clearance occurring several centuries prior to the occupation of Neolithic sites in the region (see **Section 8.4.**). At Arderrawinny, increased open environments were evidenced during the Late Mesolithic and continued until the Middle/Late Neolithic. Continued evidence for woodland openness and anthropogenic activity was exhibited at Lough Cullin following the end of the *Landnam* phase. Cereal-type pollen was recorded at this time which would indicate that Neolithic arable agriculture was being undertaken near the lake, however, no evidence for cereal cultivation was exhibited at Arderrawinny during this period.

Woodland openness and Neolithic agricultural activity ceased at Lough Cullin during the Middle Neolithic, while at Arderrawinny reduced open environments were evidenced from the Middle/Late Neolithic. Agricultural activity was again undertaken at Lough Cullin during the Late Neolithic, with evidence for cereal cultivation and grazing animals exhibited. No such activity was recorded at Arderrawinny, as evidence for open environments were at their lowest during this period. However, the presence of dry meadows or grazed swards indicated the agricultural activity during the Bronze Age.

While this section has synthesised, compared and contrasted the results of the palaeoenvironmental analyses, outlined and discussed in **Chapters 5** and **6**, the following sections explore the implications of these studies on our understanding of ecological changes and anthropogenic activity across the Mesolithic/Neolithic transition in more detail.

8.3. The 'Elm Decline' as a synchronous, chronological marker of the Mesolithic/Neolithic transition.

The investigation into mid-Holocene 'Elm Decline', outlined in **Section 7.2.**, has exhibited little evidence for a synchronous *'uniform phased event'* (Parker *et al.* 2002, 28), nor has any degree of geographical cohesion been extrapolated for this chronologically heterogenous 'event'. The results of the regional evaluation of the timing of the 'Elm Decline', demonstrated that it cannot be regarded as rapid or synchronous (cf. Whitehouse *et al.* 2014). The earliest sustained reduction in elm values in this study was at Lough Namackanbeg in Ireland West, while the latest occurrence was at Crocknaraw, also in Ireland West. The interval between the earliest and latest occurrence of the 'Elm Decline' ranged from *1310 – 1980* years. In accordance with Whitehouse *et al.* (2014, 196), this study again strongly challenges the perceived chronologically 'fixed' date for the mid-Holocene 'Elm Decline' in Ireland, and strenuously refutes the occurrence of an island-wide uniform 'event'.

However, while this study is in agreement with the Whitehouse *et al.* (2014) publication in relation to the asynchronous nature of the mid-Holocene 'Elm Decline' across the island, this study also challenges other assertions made. Whitehouse *et al.*

(2014, 191) have postulated the existence of a degree of spatial cohesion among these asynchronous date ranges for the mid-Holocene in Ireland, with the shorter (less than 700 years) date ranges designated into two spatially and temporally consistent groups (see Figure 8.2 & Figure 8.4). These two groups were viewed as representing a degree of synchroneity among certain 'Elm Decline' dates across the northern region of Ireland (*ibid.*, 196). The Group A sites of Whitehouse *et al.* (2014) were suggested to hint at an earlier, regional 'event' compared with the rest of the island, while the Group B sites were all deemed to correlate with the timing of onset of the mid-Holocene 'Elm Decline' at a number of sites in the west (e.g. Lough Sheeauns, Lough Aisling, and Glenulra Basin), in addition to sites in the south and east.

However, this spatial and temporal cohesion among certain sites in the northern region of Ireland, as espoused by Whitehouse *et al.* (2014), may not be as reliable as it may appear. While the date ranges for both Group A and B sites demonstrate a considerable degree of overlap in the images utilised in their study, shown in Figure 8.2 & Figure 8.4, these would appear to have resulted from the methodologies adopted rather than from statistical Bayesian modelling. The interpretation provided by Whitehouse *et al.* (2014) relied on the visual inspection of linear representations of the date ranges for the 'Elm Decline' to elucidate the degree of chronological overlap between sites within a geographical region. This approach is, however, quite problematic as it does not accurately reflect the true representation of the degree of probability inherent within each individual calibrated radiocarbon date range or *posterior density estimate*.

The basis of any calibrated radiocarbon date range or *posterior density estimate* is that these provide a 95.4% probability that the 'event' in question occurred within a given date range. For example, the *posterior density estimate* for the onset of the mid-Holocene 'Elm Decline' at Lough Cullin occurred between *4320 – 3990 cal BC*, indicating that there is a 95.4% probability that this 'event' occurred in an unspecified year within these two dates. However, while there is a 95.4% probability that the 'actual' date is within the full date range, this does not mean that all dates within the range are equally as probable. Therefore, the calibrated radiocarbon date range or *posterior density estimate* is expressed as a 'curve' with a varying probability density for each year of the date range. From the example shown in Figure 8.1, the probability density 'curve' indicates that while there is a 95.4% probability that the 'actual' date for the 'Elm Decline' occurred between *4320 – 3990 cal BC*, it is more probable to have occurred between *4200 – 4030 cal BC,* than before or after this range. Despite the varied probability density of each year across the range, the 'full' 95.4% probability date range is used as this ensures the greatest degree of accuracy.

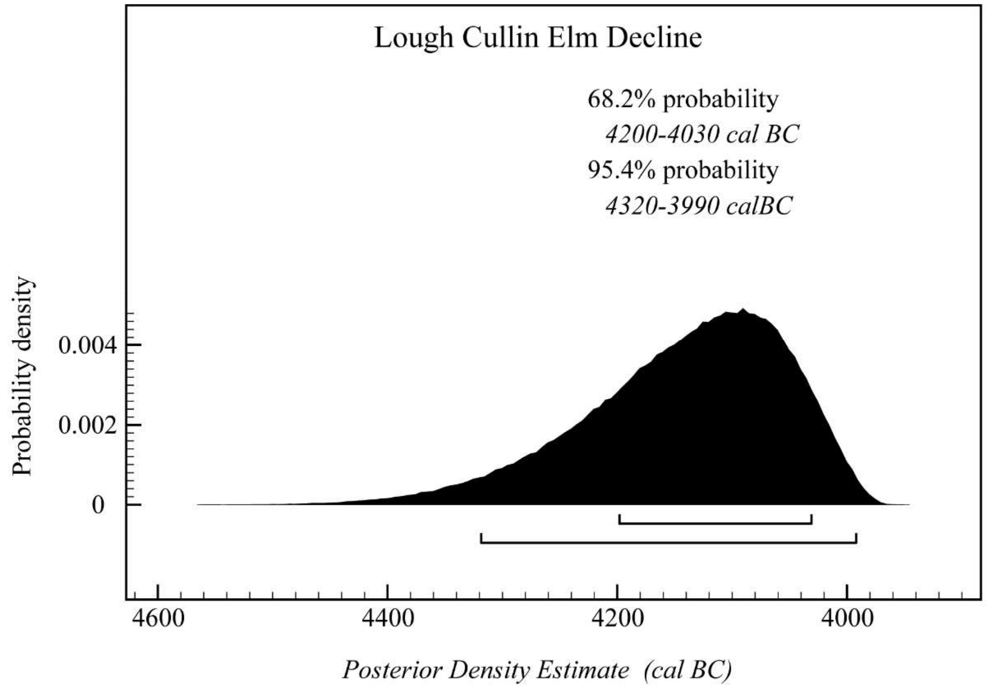

Figure 8.1 Posterior Density Estimate for the 'Elm Decline' at Lough Cullin

Therefore, the linear representation of the date ranges for the 'Elm Decline' which was employed by Whitehouse *et al.* (2014) seems to have served to inadvertently distort the dataset and indicate a degree of synchroneity which was more apparent than real. By adopting this linear representation of the date ranges, the interpretation failed to consider the varied probability density inherent within each individual date range. In effect the range of overlap between two sites within each of the groups identified, may have been from the lower probability density of both ranges and the 'event' at both sites was therefore, unlikely to have occurred contemporaneously.

As outlined in **Section 2.4.7.**, in this study the temporal relationship between sites was statistically assessed within a Bayesian framework to ensure that the probability density of each calibrated radiocarbon date range or *posterior density estimate* was accurately reflected in the model. The statistical probability of the mid-Holocene 'Elm Decline' occurring prior to, following or contemporaneously across multiple sites on a regional and island-wide basis was explored within a Bayesian model in order to build up a matrix of the relative order of this ‘event’. By utilising statistical Bayesian analysis techniques this study, therefore, represents a more robust methodological interrogation of the available dataset. While the Group A and B sites of Whitehouse *et al.* (2014), shown in Figure 8.2 & Figure 8.4, demonstrated a considerable degree of chronological overlap and possible synchroneity, the more explicit use of Bayesian analysis employed in this study would strongly refute this. Indeed, the accurate expression of these date ranges as probability density ‘curves’ rather than linear expressions may well serve to visually demonstrate this (see Figure 8.3 & Figure 8.5 in contrast to Figure 8.2 & Figure 8.4).

In this thesis a distinct lack of overall synchroneity for the mid-Holocene ‘Elm Decline’ across the island was demonstrated in the statistical probability model (see **Section 7.2.6.**), with neither of the groups identified by Whitehouse *et al.* (2014) shown to have been statistically cohesive. Of the nine sites included in Group A (*ibid.*) this thesis did not include the dates for the ‘Elm Decline’ at Altar Lough and Lough Nadourcan as the date ranges for the ‘Elm Decline’ at both sites exceeded the threshold outlined in **Section 2.4.8.**, while Garry Bog was also not included as the original publication did not explicitly provide the depths for the radiocarbon dates or the ‘Elm Decline’. Of the remaining six sites only Lough Catherine IV, Ballynagilly and Fallahogy, were shown to be statistically consistent. In contrast to Whitehouse *et al.* (2014, 192) this study did not provide evidence that these ‘*northern sites hint at an earlier, regional event compared with the west and east/south of Ireland’* as the ‘Elm Decline’ at all six sites were shown to have occurred contemporaneously with sites in the other three regions (see **Section 7.2.6.**)

Image Redacted, See Whitehouse *et al.* (2014, 195)

Figure 8.2 Date ranges for ‘Group B’ sites by Whitehouse et al. (2014)

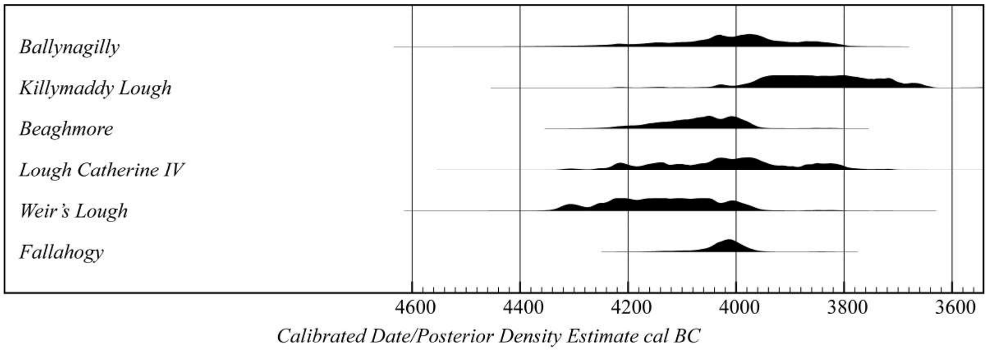

Figure 8.3 Date ranges for Whitehouse et al. (2014) 'Group A' sites from this study

Comparative with the Group A sites, the overall synchroneity of Whitehouse *et al.*'s (2014, 192) northern Group B sites was also challenged in this study. While these sites demonstrated a greater degree of synchroneity with other sites across the island (see **Section 7.2.6.)**, the probability of the 'Elm Decline' across the northern region occurring contemporaneously was considerably lower (see **Section 7.2.3.**). With Ballynahatty not incorporated into this study, as the date range exceeded the threshold outlined in **Section 2.4.8.**, at only two of the remaining seven sites was the 'Elm Decline demonstrated to be statistically consistent. This would further question whether the methodologies employed in the study by Whitehouse *et al.* (2014) were sufficiently robust as to accurately reflect the spatial and temporal relationship of the mid-Holocene 'Elm Decline' in Ireland.

What is apparent from this study of sites that have a well-dated expression of the mid-Holocene 'Elm Decline' was a conspicuous lack of geographical cohesion. While an element of chronological homogeneity existed in certain regions, this interpretation may be misleading as the majority sites did not exhibit the same chronological consistency. For example, while five of the six sites in **Group 6** are located in the Ireland West region, the remaining twelve sites in this region demonstrated no such consistency with these sites. Additionally, this study also demonstrated that this chronological cohesion existed beyond regional parameters, with the mid-Holocene 'Elm Decline' shown to have occurred contemporaneously at sites from a number of regions.

However, the relatively low number of sites which could robustly be incorporated into this study might question whether a pattern for the spread of the 'Elm Decline' can be established along geographical lines. The strong possibility exists that the sample size available for inclusion in the model, outlined in **Section 7.2.6.**, was unlikely to be sufficient for such spatial analyses, while the number of sites from the northern and western regions probably represented an additional source of bias within this analysis.

Image Redacted, See Whitehouse *et al.* (2014, 195)

Figure 8.4 Date ranges for 'Group B' sites by Whitehouse et al. (2014)

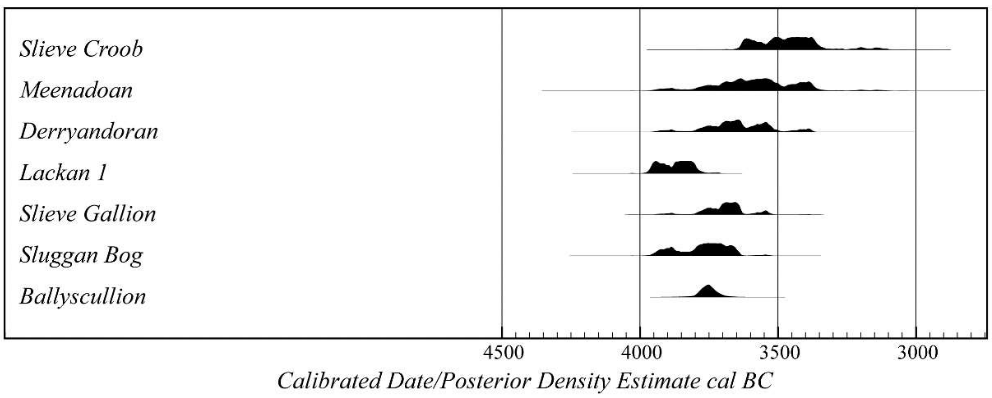

Figure 8.5 Date ranges for Whitehouse et al. (2014) 'Group B' sites from this study

As was outlined in **Chapter 1**, the principal aim of this research was to better understand the process of Neolithisation in southern Ireland, as regard the relationship between the palaeoenvironmental and archaeological records. Therefore, the 'Elm Decline' was selected for investigation based on its extensive use as a proxy chronological marker for the start of the Neolithic (O'Connell and Molloy 2001; Parker *et al.* 2002) and its perceived temporal association with anthropogenic disturbance (Whitehouse *et al.* 2014). Numerous palaeoenvironmental investigations in Ireland have demonstrated evidence for woodland instability and/or early agricultural activity following the mid-Holocene 'Elm Decline' (e.g. Mitchell 1942; O'Connell 1980; O'Connell *et al.* 1988; Molloy and O'Connell 1991; Fossitt 1994; Heery 1997; Connolly 1999; Brown *et al.* 2005; Selby *et al.* 2005; Caseldine and Fyfe 2006; Molloy 2008; Ghilardi and O'Connell 2013; Molloy *et al.* 2014). The apparent correlation between this 'event' and the adoption of Neolithic practices led to early suggestions of an anthropogenic cause for this 'event' (e.g. Piggott 1954; Mitchell 1954b; Troels-Smith 1960).

Counter arguments to this have been made by Rackman (1980) and Rowley-Conwy (1982) who questioned whether the scale and rapidity of the 'event' negated suggestions of an Early Neolithic anthropogenic cause. Over the subsequent decades several hypotheses have been postulated for this event including one or a combination of: climate change, soil deterioration, anthropogenic activity and pathogenic attack (Girling and Greig 1985; Girling 1988; Peglar and Birks 1993; Parker *et al.* 2002). However, these competing hypotheses have in large been propagated on the supposed rapid and synchronous nature of the mid-Holocene 'Elm Decline', which this thesis and others have strenuously called into question (Whitehouse *et al.* 2014; Griffiths and Gearey 2017). The potential therefore exists, that given the apparent gradual and asynchronous occurrence of the 'Elm Decline' in Ireland, anthropogenic activity may have contributed to the reduction in elm exhibited at this time. Indeed, at both Lough Cullin and Arderrawinny, this is strongly suggested. The chronological relationship between the 'Elm Decline' and the potential construction of the nearby portal tomb at Arderrawinny certainly suggests this, while the intensive clearance phase at Lough Cullin would indicate considerable anthropogenic activity immediately follow the 'Elm Decline' (see below).

While a coincidental chronological correlation between the 'Elm Decline' at their Group B sites and early farming is noted by Whitehouse *et al.* (2014, 196), this study cannot definitively support such a suggestion. At four of the sites, plus at Arderrawinny, evidence for open environments and anthropogenic activity was demonstrated to have occurred prior to the 'Elm Decline'. However, of these Clowanstown was unsuitable for the assessment of the relationship of the two 'events' due to the lack of a mid-Holocene 'Elm Decline'. Ballynagilly and Lackan, both demonstrated a clear chronological separation between the 'Elm Decline' and the start of evidence for anthropogenic activity, which would strongly question such a correlation.

Of the remaining twelve sites only Fallahogy, demonstrated a strong connection between this 'event' and the start of anthropogenic activity. The others indicated that anthropogenic activity may have occurred shortly following the 'Elm Decline' or possibly as much as up to *c.*500 years afterwards. While this study suggested that anthropogenic activity may have occurred rapidly after the onset of the 'Elm Decline' this could simply be a result of the inability of the model to accurately reflect the chronological separation between the two 'events' (see **Section 7.2.8.**).

While it may be tempting to definitively suggest such a connection, the available dataset cannot be regarded as providing sufficient information to do so. In order to maintain the robust methodological approach that this study has endeavoured to do, one must consider the evidence in its entirety. In the majority of sites incorporated in the model presented in **Section 7.2.8.**, this connection may well have occurred, however, the possibility also exists that these 'events' were separated by several centuries. By the nature of Bayesian modelling all such relationships, and in this case, the interval between two 'events' are again expressed as ranges of probability. As outlined above, this inherent probability density must be addressed for an accurate interrogation of this dataset to be achieved. Critical examination of and a complete representation of the dataset must be undertaken to ensure that the resulting interpretation is robust.

Therefore, in each of the examples outlined in **Section 7.2.8.,** a robust and stringent correlation between the start of anthropogenic activity and the mid-Holocene 'Elm Decline' can be suggested, although not definitively. The Bayesian analysis undertaken in this study can merely suggest that such a correlation may have occurred or the 'Elm Decline' may have occurred several centuries prior to the start of a phase of sustained anthropogenic activity at each site. To definitively state one or the other possibility as being correct, while failing to acknowledge the other, would simply be a deliberate misrepresentation of the data. Therefore, while archaeology is a theoretically driven, interpretative discipline, if scientific or mathematical principals are being utilised, these must be employed rigorously and, in their entirety, if interpretations are to be drawn from their results.

What this study has clearly demonstrated is the need for an awareness of the intrinsically distinct nature of the mid-Holocene 'Elm Decline' at multiple sites across the island. The heterogenous character of this 'event' necessitates that 'top-down' views of 'events', such as the 'Elm Decline', must be drawn from a mosaic of well-dated and well-defined palaeoenvironmental analyses, in which each sites is assessed on its own merits rather than as a collection of the entire dataset. Framing interpretations as to the correlation of the 'Elm Decline' with anthropogenic activity or indeed the causality of the 'Elm Decline' through such activity based on broad trends across multiple sites is inherently problematic. While studies of the 'Elm Decline' will invariably involve the need to address issues of causation, these interpretations must account for the diverse chronology and range of 'signatures' for this 'event'.

In this study, a connection between the onset of the 'Elm Decline' and Early Neolithic activity is strongly refuted based on the integrated Bayesian models outlined in **Section 7.3.** (see below), although a potential correlation between this 'event' and the construction of the portal tomb was suggested at Arderrawinny. The definition of what constitutes Early Neolithic activity (outline in **Section 3.5.3.**) and therefore, the date range for its adoption in the region (see **Section 4.5.**) may be problematic, however (see below). At Lough Cullin evidence for woodland clearance, which was almost certainly related to anthropogenic activity, was exhibited *0 – 220* years after the decline in elm. However, this was demonstrated to have no connection with the archaeological evidence for Early Neolithic activity and raises the possibility that earlier 'pre-Neolithic' activity was connected to the 'Elm Decline' at Lough Cullin (see below).

As outlined above, only at Fallahogy was a definitive chronological connection between this 'event' and the start of anthropogenic activity evidenced, while a further eleven sites, including Lough Cullin, also alluded to this. It is therefore, possible to determine that the 'Elm Decline' at these sites may have been connected to anthropogenic activity, although, this need not necessarily be equated with 'Neolithic' activity. At an additional four sites evidence for open environments predated the onset of the 'Elm Decline', which could suggest that anthropogenic activity had commenced at these sites prior to the 'Elm Decline' and could therefore indicate a causal link between the two. In contrast, however, at both Ballynagilly and Lackan, no connection between the 'Elm Decline' and anthropogenic activity can be suggested, as a clear chronological separation of several centuries was evidenced.

This would therefore indicate that while a correlation between anthropogenic activity and the onset of the 'Elm Decline' can be suggested at several sites, this is not absolute. If this correlation is accepted, this would indicate that the 'Elm Decline' at these sites was caused, either solely or in combination with other factors (Girling and Greig 1985; Girling 1988; Peglar and Birks 1993; Parker *et al.* 2002), by human activity at this time. However, to suggest that this interpretation is in general agreement across all sites would be imprudent as at Ballynagilly and Lackan the cause of the 'Elm Decline' would strenuously point to a non-anthropogenic factor. This would therefore indicate that the 'Elm Decline' across the island was a complex, multifactor, site-specific process.

8.4. The Neolithisation of southern Ireland

The overarching aim of this thesis was to better understand the process of Neolithisation, as regards the relationship between the palaeoenvironmental and archaeological records, in southern Ireland. This was achieved primarily through the application of Bayesian analysis, which served to refine and integrate the two principal proxies available for investigating human activity during the Mesolithic/Neolithic transition. The integration of the palaeoenvironmental analysis undertaken in this research with the archaeological, especially chronological, data has allowed for the formulation of new hypotheses concerning patterns of vegetation change and the timing and intensity of human activity. This research has built on recent Bayesian analysis of the Early Neolithic archaeological record, (McSparron 2008; Cooney *et al.* 2011; Schulting *et al.* 2012; 2017; Schulting 2014; McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016), by collating, analysing and synthesising published and unpublished excavated site reports from the region and undertaking Bayesian chronological modelling of relevant archaeological data. The results of which have been outline in **Chapters 3** and **4** and are now synthesised and discussed.

The chronology of the varying aspects of what has become to define the Early Neolithic in Ireland (cf. Cooney 2000; Bradley 2007; Waddell 2010; Cooney *et al.* 2011; Cummings 2017, and others), namely rectangular house structures, monumentality, cereal cultivation and domesticated animals, were assessed to refine the date for the start of Neolithic practices in the region. Also incorporated were the dates from the burial record and the more ephemeral signs of occupation and activity of the period. The Bayesian analysis of this combined archaeological dataset has provided an illuminating insight into, not only of the use of these specific features in their own right, but also into the process of Neolithisation across the region.

This analysis has established and reaffirmed the prominent position of the rectangular timber house structure during this earliest Neolithic, demonstrating these to be among the earliest features of the period. Occupation of these structures commenced in southern Ireland from *3730 – 3660 cal BC* and continued until *3640 – 3610 cal BC.* This compares well with the chronology proposed by McSparron (2008), and Cooney *et al.* (2011) for their appearance island-wide. The structures were shown to have lasted a relatively short period of between *30 – 100 years,* possibly representing three or four generations in human terms.

The significance of these structures and especially the tight chronological horizon for their construction and occupation cannot be over-estimated in the understanding of the process of Neolithisation. These structures have become the embodiment of what not only differentiates the Early Neolithic from the preceding Late Mesolithic period, but also from the Neolithic of southern Britain (Cooney *et al.* 2011, 599). The number of these houses which have been identified across the region, from Cloghers (Kiely 1999; 2003) in the west to Kilkeasy (Monteith 2010) and Newrath (Wren 2006c) in the east, and the tight horizon of the occupation may indicate a process of Neolithisation involving colonisation (cf. Cooney 2000; 2007; Peter Rowley-Conwy 2004; Bradley 2007; Smyth 2011). The rapid and almost seemingly synchronous appearance of these structures across the region, in addition to the lack of a preceding parallel certainly suggests that these represent the arrival of a new cultural phenomenon centred around a sedentary existence.

While the rectangular structures have become viewed as quintessentially Early Neolithic and have tended to attract much research attention (e.g Smyth 2006; 2007; 2011; 2013; 2014; McSparron 2008; Smyth and O'Flaherty 2015; Cooney *et al.* 2011), these are not the only manifestation of Early Neolithic settlement. Other, more ephemeral features including pits, hearths, and scatterings of post and stake-holes are also uncovered with surprising frequency in the vicinity of houses or as isolated features (Smyth 2012). These 'isolated' examples are often identified on similar terrain as the house sites and could represent the final visible remnants of temporary settlements (Pollard 2001, 316).

Activity at these Early Neolithic ephemeral sites were demonstrated to have begun in southern Ireland in *3710 – 3640 cal BC* and were in use until *3570 – 3500 cal BC.* These sites were therefore in use for a longer period than rectangular houses, *90 – 170* years, possibly representing four to six generations in human terms. While this indicates that the occupation and use of the ephemeral site began after the occupation of house sites, activity at the former ran parallel with the later phase of occupation at timber houses and continued when use of timber houses appears to have fallen out of practice. The overlapping use of house and ephemeral sites suggests that despite the supposed sedentary nature of the period (cf. McClatchie *et al.* 2014), an element of mobility persisted which would indicate that settlement patterns represented a form of 'tethered mobility' (Whittle 1997), where people were attached to a particular landscape but had a degree of mobility within it.

The continued use of ephemeral sites following the abandonment of the more structurally robust timber houses indicates a shift to a less well-defined and less sedentary lifeway in the post-'House Horizon' Neolithic. However, the presence of cereal remains at these sites demonstrates the continued reliance on arable agriculture. The end of the timber house use indicated a move towards a shifting cultivation regime where plots were not necessarily tended constantly, but would draw people back to specific places on a cyclical basis (Cummings 2017). The keeping of domesticates would have required the movement of herds to make use of the maximum amount of pasture, i.e. transhumance, or booleying, which would account for the abandonment of the sedentary settlement strategy exemplified by rectangular houses in favour of a more mobile and ephemeral settlement patterns in the post-'House Horizon' Neolithic.

The chronology of Early Neolithic burial record in the region was more problematic to decipher, as despite the presence of twenty-one extant portal and court tombs, excavated examples were rare. Only two of these monuments have been excavated, the court tomb at Baile na Móna Íochtarach/Ballynamona Lower, County Waterford (Powell 1938) and the portal tomb at Killaclohane, County Kerry (Connolly 2015). While both demonstrated activity from the Early Neolithic, no radiocarbon dates were available and so were unable to inform our understanding of burial practices in the region. Early Neolithic burial activity was therefore confined to the four excavated examples of isolated or cave burials in the region, which indicated that such activity began in *3680 – 3530 cal BC* and continued until *3630 – 3390 cal BC.*

The date range for cave burials in the region compares strongly with the date range for the start of court tomb construction in Ireland (Schulting *et al.* 2012), but is a century or more after the potential date for portal tombs (Schulting 2014, see below). Considering the almost complete lack of court tombs in the region, this would indicate that cave burials represent a different, but broadly contemporary, funerary tradition in the region than the court tomb tradition of the northern half of the island (Cummings 2017, 92). The comparison between the cave burials of the region and portal tombs is less certain. While one of the twenty such examples in the region has recently been excavated, the results of this have yet to be published. In this study the hypothesis that the date for portal tomb construction was broadly similar to the only well dated example, Poulnabrone (*ibid.*; **Chapter 3; Chapter 7;** see below), was applied, which would indicate that cave burial activity occurred after the start of the portal tomb tradition. Therefore, while the utilisation of caves for mortuary practices may account for the lack of court tombs in the region, it does not offer insights into the general absence of the portal tombs in the western half of the region. The potential does exist that if portal tombs were the earliest expression of the Neolithic, this was largely confined to the eastern half of the region.

While the individual Bayesian models for settlement and funerary practices, outlined in **Section 4.4.**, have provided interesting insights into the understanding of these sites in their own right, the analysis of the combined dataset provided a far more robust understanding of the start of the Neolithic in the region. To explore hypothesis regarding the adoption of Neolithic practices in the region, three separate Bayesian models were undertaken (see **Section 4.5.**). Of these, only two were shown to be statistically robust and therefore the implications of these are now discussed.

The first model provided a date range of *3740 – 3680* for the introduction of Neolithic practices in the region and indicated these continued until *3550 – 3510 cal BC*, which proposed a duration of Early Neolithic activity in southern Ireland of between *130 – 200* years. This model operated under the assumption that all aspects of what defined the Early Neolithic in the region (see **Section 3.5.3.**) began at the same time. However, it would appear that house construction in the region occurred prior to activity at ephemeral sites and burials (see **Section 4.5.**). Therefore, an additional model (3) operated under this assumption which indicated a slightly earlier date of *3760 – 3660 cal BC* for the introduction of Neolithic practices and a date range of *3640 – 3480 cal BC* for the end of the Early Neolithic in the region, proposing a duration of Early Neolithic activity in southern Ireland of between *30 – 180* years.

Both models (1 and 3) constructed as part of this research are comparable to the results for Model 2 by Cooney *et al.* (2011) and if precise, the Neolithic began quite rapidly in the region, with occupation sites associated with Early Neolithic material appearing from *c.*3750 cal BC. The apparent swiftness of this appearance, in addition to the uniform nature of house structures and associated material culture would further attest the arrival of Neolithic migrant groups from the middle of the 38th century cal BC. This would appear to support the notion of colonist as the primary drivers of this new cultural phenomenon as espoused by Sheridan (2003a; 2003b; 2004; 2010) and others.

However, the possibility of an earlier, less uniformly adopted Neolithic presence, may be found at Ferriter's Cove, Kilgreany Cave and in certain pollen records (see below;

Chapter 5; Chapter 6; Chapter 7; also O'Connell and Molloy 2001; Whitehouse *et al.* 2014, and others) in addition to the early date of 4680 – 4350 cal BC (5660±67, *UBA-38827*) from residue analysis of Lough Gur Class 1a pottery (Cleary pers. Comm.). In both models, when the radiocarbon determinations from early domesticates were included, the statistical robustness was greatly reduced (see **Section 4.5.**). This would suggest that the dates for domesticates from Ferriter's Cove (*OxA-3869*) and Kilgreany Cave (*OxA-4269*) were demonstratively different from the wider set of dates for Early Neolithic activity elsewhere in the region. The implications of which were that either these represented outliers within the chronological sequence for the introduction of Neolithic practices in the region or a considerable time lapse existed between the introduction of domesticates and the introduction of the remaining elements of the Neolithic 'package', namely cereal cultivation and timber houses. The early cattle bones from Ferriter's Cove and Kilgreany Cave remain somewhat of an enigma in this context in terms of whether these are isolated examples or part of some wider, as yet unidentified pre-3750 cal BC Neolithic activity.

While these Bayesian models of the Early Neolithic sites have provided interesting insights into the process of Neolithisation in the region, several questions also remained to be addressed. It was envisaged in this research that the integration of the archaeological and the palaeoenvironmental data would further enlighten the understanding of the transition to agriculture in the region. As outlined in **Chapters 2, 4** and **7**, this was achieved through the implementation of a Bayesian programme, the results of which are synthesised and discussed below.

As outlined in **Sections 7.2.** and **8.3.** above, contrary to previous interpretations on the mid-Holocene 'Elm Decline' (O'Connell and Molloy 2001; Parker *et al.* 2002), this event has been shown to have been asynchronous across the island. This has led to suggestions that this 'event' was related to the activities of early farming groups (Whitehouse *et al.* 2014, 196). However, at both sites investigated as part of this research, no connection between the archaeological evidence for the start of the Neolithic and the 'Elm Decline' was exhibited, as the integrated Bayesian models demonstrated that it occurred prior to the start of the Early Neolithic (see **Sections 4.5.** and **7.3.**). This would imply that the cause of the 'Elm Decline' in the region was unrelated to Early Neolithic anthropogenic activity. However, the potential for a connection between the 'Elm

Decline' and Mesolithic activity, or alternatively archaeologically invisible or as yet unrecognised Neolithic activity is strongly suggested.

When the date ranges for the 'Elm Decline' at each site was compared with the start of primary use at Poulnabrone (Schulting 2014), under the assumption that this represented the date range for broader portal tomb construction, it was shown to have occurred prior to the start date for portal tomb use at Lough Cullin. This indicates that this 'event' was almost certainly unrelated to anthropogenic activity at least as far as portal tomb construction and use is concerned. However, a correlation between the onset of the 'Elm Decline' at Arderrawinny and the potential construction of the nearby tomb was intimated. The model indicated that date range for the start of the primary use phase at Poulnabrone occurred contemporaneously with the 'Elm Decline' at Arderrawinny, or shortly thereafter. If the date range for portal tomb construction at Poulnabrone and Arderrawinny were broadly similar, then this indicates that anthropogenic activity was linked in some form to the onset of the mid-Holocene 'Elm Decline' at Arderrawinny.

The comparison of the chronological relationship between the start of the Neolithic and woodland clearance at Lough Cullin indicated that the initiation of the *Landnam* phase occurred prior to the start of occupation at the Early Neolithic archaeological sites of the region. The woodland clearance was therefore not related to activity at the Early Neolithic sites incorporated into this study, at least as far as the currently available dataset indicates. This assertion was supported by the indication that the peak in *Landnam* activity also occurred prior to onset of the Neolithic. This would further question the connection between the Early Neolithic communities represented at the archaeological sites in question and the woodland clearance at Lough Cullin, and raises questions as to whether these sites represented the earliest expression of anthropogenic activity and environmental impact in the region. Indeed, based on the model employed in **Chapter 7**, it is difficult to associate the archaeological evidence for the Early Neolithic with the phase of *Landnam* exhibited at Lough Cullin as this 'event' ended prior to the occupation of the Early Neolithic archaeological sites in the region.

The chronological separation between woodland clearance at Lough Cullin and the Early Neolithic archaeological record suggests that these do not represent the earliest evidence of anthropogenic activity in the region. Earlier archaeological evidence may be forthcoming in the form of the remains of domesticates recovered from Kilgreany Cave (Molleson 1985-6; Woodman *et al.* 1997; Dowd 2002). While the *Landnam* at Lough

Cullin occurred before the date for cattle bone from Kilgreany Cave, it was however, earlier than the date the peaks of the *Landnam* phase. This could indicate the presence of domesticates in the region at the time when the most intense phase of woodland clearance was occurring. Therefore, palynological evidence for open habitats near Lough Cullin may be as a result of some pre-'house horizon' and 'arable' Neolithic. In light of the date range for the *Landnam* at Lough Cullin, the potential exists that this domesticate represented some form of early agricultural practices.

Whether this represents evidence for the arrival of the 'Breton' or the 'Cross Channel-west' Neolithic in Ireland (Sheridan 2010) or indigenous adoption of selective agricultural practices (Thomas 1988; 2004; 2013) is more difficult to decipher. As outlined in **Section 3.5.4.** Sheridan (2010) postulates a multi-phased migration of Neolithic groups from southern Brittany, the Nord-Pas de Calais region of northern France and the low countries in the final centuries of the fifth and the early fourth millennium cal BC. She suggests the appearance of small megalithic closed chambers and small passage tombs (Sheridan 2003a; 2003b; 2004; 2010), in addition to the Carinated Ware tradition and other aspects of the Neolithic 'package' as an indication of this migration. However, this study (see **Chapter 4**) and others (Cooney *et al.* 2011; Schulting 2014; McLaughlin *et al.* 2016) provided no evidence for tomb construction or the appearance of the Neolithic repertoire prior to the $39^{th}/38^{th}$ century cal BC. This would question whether the *Landnam* at Lough Cullin was representative of either 'strand' of Neolithic colonisation as envisaged by Sheridan (2010).

Alternatively, this could also represent, as Sheridan (2010, 91-92) and Tresset (2003) have argued for the cattle bone at Ferriter's Cove, another early 'failed' Neolithic colonisation. Sheridan (2010, 92) argues for a small scale immigration of agropastoralists from France as the source of these pre-Neolithic domesticates, with this initial pioneering attempt at establishing the Neolithic way of life failing due to an absence of a critical mass of people (Sheridan 2003a; Tresset 2003). The occurrence of further 'failed colonisation' attempts is not suggested by her on the grounds that evidence for a similar pre-'Carinated Bowl Neolithic' is as yet unrecorded (*ibid.*, 92). However, this assertion is based on an assumed date of *c.*4000 cal BC for the introduction of such a Neolithic, an assertion which is not supported in this study (see **Chapter 4**) or by previous Bayesian studies on the start of the Neolithic (Cooney *et al.* 2011; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Solely considering this idea of 'failed colonisation', the domesticated cattle bone from Kilgreany Cave may be seen as representing a similar unsuccessful, pre-3750 cal BC attempt. However, the intensity and duration of woodland clearance exhibited at Lough Cullin would appear to have been too great to represent an unsuccessful early migration of European Neolithic farmers.

This notion of a 'failed colonisation' is predicated not only on the absence of such animals in Ireland prior to the Neolithic, but also on the assertion that the insular nature of the Late Mesolithic in Ireland refutes the possibility that the presence of domesticates in such contexts was derived from Mesolithic contacts with agricultural societies elsewhere (Sheridan 2010, 92). However, the concept of an insular Irish Late Mesolithic may not as reliable as has been suggested (see **Section 3.4.**). The combined evidence of the early *Landnam* at Lough Cullin and the cattle bone from Kilgreany Cave may be an indication of the gradual and selective adoption of aspects of the Neolithic by Mesolithic groups in the centuries around 4000 cal BC (Sensu Thomas 1988; 2004; 2013).

This adoption of selected facets of the Neolithic by Mesolithic groups may have resulted from what Zvelebil and Rowley-Conwy (1986) termed the 'availability phase', where farming and other aspects of the Neolithic 'package' become known to hunter-gather *via* exchange networks or social interactions. If the stylistic variation of the Late Mesolithic lithic repertoire from its British and European counterparts (see **Section 3.4.**) does not in fact represent the degree of social, cultural and economic interaction between these groups, the possibility exists that Late Mesolithic groups in Ireland were aware of agricultural practises. In contrast, to the views of Sheridan (2010, 91-92) these pre-3750 cal BC domesticates may represent the evidence of interactions with Neolithic communities in continental Europe and thus the 'availability phase' as outlined by Zvelebil and Rowley-Conwy (1986). Even if the domesticates from Ferriter's Cove represented the remains of a joint of meat (Whittle 2007) rather than the presence of actual animals, this would still indicate the possibility of an 'availability phase' occurring towards the end of the Late Mesolithic, as such communities would be aware of the utilisation of such animals for subsistence practices.

Interactions between Late Mesolithic communities in Ireland and continental European agriculturalists would be in keeping with the situation elsewhere in northern Europe (e.g. Louwe Koojimans 2007; Vanmontfort 2007; Thorpe 2015). Evidence for such a selective adoption of otherwise Neolithic traits has been postulated in Mesolithic/Neolithic interface zones in parts of north-west Europe. In the Lower Rhine

Basin, the arrival of the *Linearbandkeramik* (LBK) Neolithic prior to the fifth millennium cal BC resulted in interactions with pre-existing Mesolithic groups to the north (Thorpe 2015, 217; Cummings 2017, 32). The use of ceramics by *Swifterbant* hunter-gatherer communities suggests that they began to incorporate selected facets of the Neolithic 'package' into an otherwise Mesolithic lifestyle (Louwe Koojimans 2007, 296; Raemaekers and Roever 2010), while a similar ceramic phase, was also noted in the southern Scandinavian *Ertebølle* Mesolithic (Thorpe 2015, 217).

However, in the *Ertebølle* Mesolithic no evidence for the uptake of agriculture has been forthcoming (*ibid.*), while the quantities of domesticated animal bones from *Swifterbant* contexts have been suggested to represented evidence of exchange networks with Neolithic groups rather than the adoption of pastoralism by Mesolithic communities (Louwe Koojimans 2007, 297), *sensu* Whittle (2007) in the case of domesticates at Ferriter's Cove. Despite evidence for an 'availability phase', there does not appear to have been any gradual transition to or adoption of agricultural practices by these hunter-gather groups (*ibid.*), which may question why such an adoption would have occurred in the Irish Late Mesolithic. If hunter-gathers in northern Europe, who probably interacted with agricultural communities on a more recurring basis than the episodic nature of Mesolithic-Neolithic contact in the Irish Late Mesolithic, did not adopt agricultural practices, why and how would hunter-gather groups in Ireland do so?

The answer to this may be alluded to in the question itself, the intermittent availability of such resources in the Irish Late Mesolithic may have created a greater need for the adoption of aspects of the agricultural lifestyle. The relative paucity of the faunal assemblage (see **Section 3.2.**) may have increased the desirability of domesticates to hunter-gather groups in Ireland, while the availability of wild herbivores may have reduced the attractiveness of agriculture to similar groups in northern Europe and Britain. Furthermore, in a highly-mobile society, as the Late Mesolithic in Ireland has been suggested to be (see **Section 3.3.**), the transition to a pastoralist society would not have been as seismic a change as perhaps the adoption of other aspects of the Neolithic would have been. Pastoralism could have been incorporated into a transient lifestyle much more readily than other aspects of the Neolithic package such as cereal cultivation or house construction.

The restricted number of pre-3750 cal BC domesticates which have been recovered to date may be said to undermine this suggestion of early pastoralism, however, this may be accounted for in a number of explanations. The very limited number of substantial archaeological sites from between *c.*4500 – 3750 cal BC is certainly a potential contributing factor to the dearth of knowledge of this period (see **Section 3.3.**). Taphonomic issues and recovery biases (see **Section 4.2.**) may also account the low number of such discoveries, as the acidic nature of Irish soil is not conducive to survival of faunal remains. This can be evidenced from the low frequency of animal bone recovered during the post-3750 cal BC Neolithic (see **Appendix B**). While lipids analysis of Early Neolithic ceramics has indicated dairying was undertaken in this period (Smyth and Evershed 2015a; 2015b), the occurrence of cattle bones in these contexts is relatively rare. It is not inconceivable then that greater numbers of domesticates were present prior to *c.*3750 cal BC than has so far been identified and that the intensive phase of woodland clearance at Lough Cullin, which predated the appearance of the 'House Horizon' and cereal cultivation, related to a gradual and selective adoption of animal husbandry by existing hunter-gatherer groups.

However, the possibility that this intense phase of woodland clearance represents Mesolithic activity near the lake cannot be overlooked. Mesolithic anthropogenic activity has been suggested to have caused similar environmental impact elsewhere (e.g. Smith 1970; Simmons and Innes 1996; Innes *et al.* 2003; Warren *et al.* 2014). These woodland disturbances may have been a deliberate attempt by Mesolithic hunter-gather communities to encourage or exploit open habitats (Warren *et al.* 2014) to facilitate hunting (Mellars 1976; Simmons and Innes 1996) or to encourage the growth of wild foodstuffs (Bye 1981; Smith 2011). While the prominent position of coastal sites in the Late Mesolithic is well-attested (see **Section 3.3.**), the recovery of Late Mesolithic fish baskets (FitzGerald 2007; McQuade 2008) and wooden platforms at Clowanstown (Mossop and Mossop 2009) and at Mitchelstown East (Woodman and Anderson 1990, 386), in addition to the wooden trackway at Inch Strand near Lough Gara (Fredengren 2002, 120), also demonstrate the potential for the exploitation of inland rivers and lakes. The potential therefore exists that the woodland clearance at Lough Cullin represented the effects of Late Mesolithic activity and utilisation of the lake for aquatic resources.

In similarity with Lough Cullin and indeed with Arderrawinny (see below; **Chapter 6**), evidence for open environments was also exhibited at Clowanstown (Gearey *et al.* 2010) during the Late Mesolithic. Although not on the scale exhibited at Lough Cullin, the degree of openness and archaeological evidence for a Late Mesolithic presence at Clowanstown seems to indicate that hunter-gather groups may have engaged in some form of woodland clearance or management of existing open areas. However, as outlined in **Chapter 5**, the *Landnam* exhibited at Lough Cullin appeared to have been restricted to trees growing on the drier mineral soils away from the lake edge. The lack of strong evidence for clearance of the alder-willow carr woodland, which probably fringed the lake, would seriously question whether the phase of woodland clearance was related to access and the exploitation of lacustrine resources by Mesolithic hunter-gatherer groups.

At Arderrawinny, as has been outlined in **Chapter 6**, the palynological signal for Early Neolithic anthropogenic activity is less conclusive and more difficult to decipher. While the presence of open environments commenced several centuries prior to the mid-Holocene 'Elm Decline' and the start of the Neolithic in southern Ireland (see **Section 7.3.**), an increase in ribwort plantain was exhibited at *3810 – 3520 cal BC.* The results of the integrated Bayesian analysis demonstrated that this increase occurred after the hypothesised date range for the start of portal tomb use and the start of the Early Neolithic, as outlined in **Section 4.5.** This may indicate the increased levels of vegetation openness resulted from Early Neolithic anthropogenic activity related to the portal tomb at Arderrawinny (see **Section 8.5.**).

However, the continuous presence of open environments for several centuries prior to the start of the Neolithic may also indicate that this openness related to the edaphic conditions of the sampling basin, which probably prevented the formation of a closed woodland in the local landscape. The potential that this post-'Elm Decline' increase in indicators of open environments was unrelated to anthropogenic activity cannot be overlooked. While the presence of ribwort plantain and other secondary anthropogenic indicators in pollen diagrams is taken as a very important signal for the recognition of anthropogenic activity in such studies (Behre 1981; 1986), it must be borne in mind that many of the common anthropogenic indicators are native plants, and these apophytes also occur naturally in woodland openings. However, considering the presence of the probable Early Neolithic portal tomb and its close temporal association with both the 'Elm Decline' and the increase in anthropogenic indicators, an Early Neolithic presence can be suggested at Arderrawinny. The form this presence took and the significance of this to our understanding of Neolithic practices and tomb construction is discussed in **Section 8.5.**

Cereal cultivation

The earliest records of cereal-type pollen is recorded in pre-'Elm Decline' levels at Arderrawinny, dated to *5650 – 5350 cal BC*, while at Lough Cullin, it was recorded following the reduction in elm at *4210 – 3960 cal BC.* In southern Ireland, a further example of the identification of such early cereal-type pollen was at Cashelkeelty, County Kerry (Lynch 1981), where *Triticum* (wheat) and *Hordeum* (barley) cereal-type pollen grains were recorded from 4950-4470 cal BC (Waddell 2010, 26). However, the significance of these in terms of evidence for the start of arable activity in the region is highly debatable. While palynological evidence for pre-Neolithic cereal-type pollen has been recorded in several pollen profiles from Ireland (e.g. O'Connell 1987; O'Connell *et al.* 1999; O'Connell and Molloy 2001), Britain (Edwards and Hirons 1984) and in much of north-west Europe (see Behre 2007), the reliability of these have been questioned (Behre 2007; Tinner *et al.* 2007) and in more recent times largely dismissed as large pollen grains produced by non-cultivated grasses (O'Connell and Molloy 2001, 118; Tweddle *et al.* 2005).

Behre (2007) in a review of the palynological evidence for Mesolithic agriculture in Europe questioned the reliability of pre-Neolithic cereal-type pollen identification due to a number of factors. The crucial point was the difficulty in distinguishing cereal pollen from large wild grass pollen, as morphologically, both show that in size, as well as in the pores and the fine structure of the pollen wall, there is some overlapping between wild grasses and cereals. Secondly the identification of cereal-type pollen, without the accompanying ruderal taxa usually indicative of arable activity (Behre 1981; 1986), was considered to be insufficient evidence for arable farming. Behre (2007), however, also notes that even if these anthropogenic indicators are present, many of these taxa are native and occur in small woodland openings, whether these are natural or created by the Mesolithic activity. Therefore, the presence of these ruderal taxa must also to be considered with caution if taken as support for arable activity. Behre (2007) also noted that in several pollen profiles, the authors point to the occurrence of cereal-type pollen in Late Mesolithic contexts but fail to mention its occurrence in earlier parts of the same sequences. Indeed, in the Irish palynological records, such cereal-type pollen has been recorded as early as the late-glacial period (e.g. O'Connell *et al.* 1999).

Of most significance to the reliability of early cereal-type pollen, however, was the lack of secure archaeobotanical evidence, in the form of well dated carbonised cereal grains, from pre-Neolithic contexts. Analysis of cereal macrofossils from archaeological contexts strongly suggests that cereal cultivation in Britain and Ireland did not commence prior to *c.*4000 cal BC (Brown 2007). Brown (2007) in a study of charred cereal macrofossil remains from 63 sites between Britain and Ireland, suggests that the onset of the cereal cultivation at a minority of sites occurred between *c.*4000 – 3800 cal BC, with the majority dating to between *c.*3800 – 3000 cal BC. Brown (2007), further suggested that cereal-type pollen grains found earlier than this time were more probable to have derived from wild grasses rather than cultigens. More recent evaluations of the macrofossil record, such as the Heritage Council INSTAR-funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland*, has placed the onset of arable activity in Ireland several centuries later at *c.*3750 cal BC (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). This occurrence of early cereal-type pollen cannot therefore be considered reliable evidence for arable activity and the pre-'Elm Decline' cereal-type pollen recorded at Arderrawinny and Cashelkeelty (Lynch 1981) more plausibly represented large non-cultivated grass pollen, such as floating sweet grass, rather than evidence for cereal cultivation.

While the Neolithic communities represented in the archaeological record of the region played no role in the *Landnam* 'event' at Lough Cullin, continued evidence for open environments and agricultural activity following the end of the major clearance phase was exhibited. Open habitats on the mineral soils near Lough Cullin did not come to an end until *3640 – 3480 cal BC,* which occurred after the start of Early Neolithic activity as exhibited in the archaeological record. The relationship between the post-*Landnam* signal for anthropogenic activity and Early Neolithic agriculture is further supported with the comparison of the date ranges for cereal cultivation and the archaeological record.

The evidence for cereal cultivation recorded from *3820 – 3570 cal BC* occurred after the start of the Early Neolithic and after the start of cereal cultivation in the region. This would imply that the arable activity indicated in the pollen record is chronologically consistent with the archaeological evidence for cereal cultivation exhibited in the broader Early Neolithic landscape. However, the earliest palynological signal for cereal cultivation, recorded at *3920 – 3690 cal BC* occurred prior to the onset of the Early Neolithic, as expressed in the archaeological record. This would have significant implications for the timing of the start of arable activity in the region, especially considering the lack of archaeological evidence for cereal cultivation in the region prior to *3750 – 3690 cal BC* (see **Section 4.4.7.)** or indeed across the island (cf. McClatchie *et al.* 2014) before *c.*3750 cal BC.

However, this date range for the start of cereal cultivation is overwhelmingly predicated on the number of cereal grains recovered from Early Neolithic houses. As has been outlined in **Section 4.4.**, research interests have tended to disproportionately focus on such monuments and the possibility exists that this has led to a bias in the archaeological record of the Early Neolithic. Also, the possibility that these do not in fact represent the earliest archaeological expression of the Neolithic has been alluded to elsewhere (cf. Danaher 2007; Schulting 2014). Therefore, the arable activity at Lough Cullin prior to the archaeologically defined 'Neolithic' may support the notion of an earlier transition to agriculture, with certain Neolithic 'practices' occurring prior to the 'House Horizon' in the region.

The integration of both the palaeoenvironmental (**Chapters 5-6**) and archaeological data (**Chapters 3-4**) through the use of Bayesian statistical analysis has provided an illuminating insight into both the ecological history and the nature of the transition to agriculture in the region. At neither site did the mid-Holocene 'Elm Decline' occur in association with the start of the Early Neolithic in the region, however, a correlation between the construction of the portal tomb and the 'Elm Decline' is suggested at Arderrawinny. While evidence for an intense phase of woodland clearance was exhibited at Lough Cullin, this has been shown to have been unrelated to start of the Neolithic in the region, at least as far as the 'House Horizon', cereal cultivation and tomb construction is concerned.

While Mesolithic hunter-gatherers may have been responsible for this clearance phase, the correlation between the date for this and the evidence for pre-3750 cal BC domesticates in the region make a compelling argument for the presence of early pastoralists. These early pastoralists may have represented the proposed 'Breton' or the 'Cross Channel-west' Neolithic strands of migration to Ireland as envisaged by Sheridan (2010), however, the lack of evidence for all other facets of the Neolithic repertoire at this time may undermine this argument. Likewise, the potential that this represents another 'failed' Neolithic colonisation (Sheridan 2003a; 2010; Tresset 2003) is unlikely considering the scale and duration of the *Landnam* phase of between *140 – 530* years.

Alternatively, this 'pre-Early Neolithic' phase of woodland clearance and anthropogenic activity may signify, as suggested by Thomas (1988; 2004; 2013), the selective and gradual adoption of certain agricultural practices by indigenous hunter-gatherer groups. The time lapse between the date for the *Landnam* at Lough Cullin, early domesticates and the arrival of the 'full Neolithic package' suggests that certain agricultural practices had reached Ireland in the centuries prior to the introduction of other facets of the Neolithic. The arrival of the 'full', 'House Horizon', arable Neolithic was therefore, the culmination of a much more gradual transition to agriculture than has been suggested (e.g. Sheridan 2010; Cooney *et al.* 2011; Whitehouse *et al.* 2014).

This is not to say that indigenous hunter-gatherers were the sole and principal drivers of the adoption of all 'things' Neolithic. As referred to above, the apparent synchronous and rapid uptake of rectangular timber houses, cereal cultivation and probably ceramic production does strongly support the colonist model of Neolithisation. The potential exists that groups of migratory groups began to arrive in Ireland in the 38th century cal BC and with them arrived additional elements of the Neolithic 'package', although this again may be problematic as it equates 'people' with 'things' (see **Section 3.4**). However, the '*hints'* of earlier farming (Whitehouse *et al.* 2014, 1) can also not be ignored. While the occasional bone of early domesticates, examples of pre-3750 cal BC woodland clearance and archaeological 'anomalies' can be overlooked, how many of these examples are necessary to be viewed as variations rather than outliers. This study does not refute that continental European migration did not occur during the Neolithic, but it does suggest that Mesolithic groups may not have been passive bystanders in the transition to agriculture.

8.5. Portal tombs and their palaeoenvironment

The function of megalithic tombs and the role they played in the development of new complex social and 'ritual' systems has been discussed for some time (Shee Twohig 1990; Sherratt 1995; Jones 2007; Müller 2010; Mercer 2014). However, the relationship between megalithic tombs and their surrounding landscape is not fully understood, in particular their association with woodland clearance. The topographical position of many of these monuments has led to the assumption that the surrounding woodlands were directly opened to facilitate construction (Andersen 1992) and remained so in order to ensure visibility in the surrounding landscape (Cummings and Whittle 2003). Although the work of Demnick *et al.* (2008) in central Germany suggests that megalithic tombs in the region remained within a closed woodland canopy for much of the Neolithic. Knowledge of their environmental setting during the Neolithic is also particularly lacking, it is uncertain to what extent these early megalithic monuments were integrated into agricultural landscapes or remained segregated from the everyday in reserved 'ritual' places.

Despite a lack of clarity on the exact nature of anthropogenic activity at Arderrawinny (see **Chapter 6** and above), the unexcavated portal tomb does provide evidence for an Early Neolithic presence in the region. If a similar construction date for the portal tombs at Poulnabrone (Schulting 2014) and Arderrawinny is assumed, then open environments almost certainly existed before the construction of the portal tomb. This would suggest that the portal tomb at Arderrawinny was constructed in an already largely open landscape, with the creation of open environments at Arderrawinny unrelated to Early Neolithic anthropogenic activity. The evidence from Arderrawinny was sufficient to suggest that there were open habitats locally during the Mesolithic and while many authors suggest deliberate human causation for similar situations elsewhere (e.g. Smith 1970; Simmons and Innes 1996; Innes *et al.* 2003), a natural cause cannot be overlooked as such openings would leave an identical signal (Brown 1997). It is highly likely given the scale and duration of woodland openings during the Mesolithic that this resulted from natural processes rather than human impact.

However, it does suggest that the landscape setting for the construction of the nearby portal tomb was possibly a conscious decision to utilise an already open landscape regardless of the cause of such openings. This deliberate selection of open landscapes may also be the case for the megalithic monuments at Ballynew, County Galway. The Ballynew portal tomb is situated *c.*50m from Lough Sheeauns (Molloy and O'Connell 1987; 1991) where palynological analysis has suggested a similar localised open habitat environment in the pre-'Elm Decline' landscape from *4190 – 3770 cal BC* (see **Section 7.2.8.**). A similar environmental setting for megalithic monuments is noted at various examples along the Irish Sea coastline of north Wales (Cummings and Whittle 2003). The passage tomb at Barclodiad y Gawres, on the west coast of Anglesey appears to have been constructed within a similarly scrubby woodland landscape, which also exhibited signs of open habitats (Powell and Daniel 1956), while the megalithic monuments at Trefignath

(Greig 1987), and Gwernvale (Britnell and Savory 1984) also suggest that construction occurred within an already relatively open environment. It is therefore reasonable to suggest that this tomb was deliberately positioned within a predominantly open environment, though it must be stated that the environmental settings of megalithic monuments varied considerably, and some were constructed with woodland contexts (Demnick *et al.* 2008).

At Arderrawinny, it would appear that the megalithic monument was constructed within a relatively open environment and may have provided a visible symbol for the existence of an early farming community. The construction of the megalithic monument likely represented a symbol of permanent occupation of land, an occupation which necessitated the building of a durable statement about the nature of Neolithic society (Sherratt 1995). The question remains as to whom this statement was addressed? Whether it was the symbol of newly established Neolithic community to the wider indigenous Mesolithic society, or as Sherratt (1995) suggests as an instrument of conversion of foragers to the economic, social and ideological practices of the Neolithic. In either of these cases the choice of a pre-existing open landscape setting would almost certainly be appealing for those wishing to convey this message. However, the lack of evidence for Mesolithic activity, may raise questions about why this location would be best suited for this purpose. Conversely, the erection of the portal tomb may have been to provide a focal point within the landscape for a wider dispersed Neolithic communal group.

It is uncertain to what extent these early megalithic monuments were integrated into agricultural landscapes or remained segregated from the everyday in reserved 'ritual' places. Several studies from northern Europe have demonstrated a degree of complexity in Neolithic landscape, with a differentiation between agricultural activity, settlements and burial or 'ritual' contexts. Investigations from Sweden (Sjögren 2010), Denmark (Andersen 2010) and Germany (Sadovnik *et al.* 2012; 2014) indicate a spatial separation between megalithic tombs, settlements and cultivation areas. In Ireland, however, the picture is less clear, evidence from Ballynahatty, County Down (Plunkett *et al.* 2008) indicates that megalithic monuments were constructed within a domesticated landscape. Agricultural activity appears to have preceded the construction of the passage tombs and land-use in the vicinity of Ballynahatty did not change in character after construction. However, it must be noted that this relates to the construction of a Middle Neolithic passage tomb within an already established cultivation and settlement landscape and little evidence exists for the environmental setting into which the earlier portal or court tombs were constructed.

While portal tomb construction and use at Arderawinny may have centred on this naturally occurring open habitat, evidence for further clearing (a *Landnam* phase) or agricultural activity is less clear. The post-'Elm Decline' increase in ribwort plantain representation occurred after the start of the Early Neolithic in southern Ireland and may be said to provide evidence for an Early Neolithic presence in the vicinity of the sampling site. The presence of ribwort plantain is generally ascribed as an indicator of anthropogenic (cf. Behre 1981; 1986), especially agricultural activity, however, considering the largely uninterrupted record of this taxon it may be unwise to infer its presence in post-'Elm Decline' levels as evidence of a Neolithic *Landnam* phase at Arderrawinny. The absence of cereal-type pollen during the Neolithic refutes the presence of arable fields close to the portal tomb, while its limited representation during the in the Bronze Age may indicate their presence during the later wedge tomb construction phase (O'Brien 1999).

The lack of a clear signal for cereal cultivation could be seen as evidence that despite some possible signals for anthropogenic impact, the megalithic monuments of the area were not incorporated into the settlement and cultivation landscape of the Neolithic in south-west Ireland. This lack of settlement activity could imply that the landscape around Arderrawinny was viewed as incompatible with arable agricultural activity, perhaps as a result of the unsuitable local edaphic conditions. It may also represent the spatial segregation of settlement from 'ritual'. The permanently open landscape may have been seen as unusable for agricultural activities or viewed as a special location, not associated with habitation. The construction of a megalithic monument would have therefore provided an enduring symbol of an Early Neolithic community which existed within the wider landscape but lacked a physical presence locally.

It is unwise, however, to suggest that what was occurring at in south-west Ireland was a template for megalithic construction across Ireland. Lough Sheeauns, in contrast to Arderrawinny, exhibits a pronounced *Landnam* phase in the immediate post-'Elm Decline' period, with evidence for likely pastoral and possible arable agricultural activity, suggesting that megalithic monuments may have been incorporated into a wider Neolithic landscape. While this implies that the place of megalithic monuments within Neolithic society varied considerably throughout Ireland, it would appear that in the context of

Arderrawinny at least, a differentiation between landscapes of cultivation, settlement and 'ritual' may have existed. Conversely, if an Early Neolithic community was present locally, it may have been of such a small scale as to render its environmental impact invisible in the palynological record. Given the pre-existing open landscape environment, it is not inconceivable that such a situation could have occurred. Alternatively, given the likely unsuitable edaphic conditions, Early Neolithic agriculture in this region may have taken on a pastoral rather than arable component, which again would be difficult to distinguish in the relatively open landscape around Arderrawinny.

Chapter 9 - Conclusions and future research

9.1. Introduction

The following chapter outlines the principal conclusions of this thesis, including the main findings of the two palaeoenvironmental assessments which have been undertaken as part of this study and the implications of these on the understanding of the timing and nature of the adoption of Neolithic practices in the region. Additionally, this chapter briefly details the major findings of the Bayesian statistical comparisons between radiocarbon-dated palaeoenvironmental records and independently dated archaeological sequences, especially, the relationship between the palynological 'events', such as the mid-Holocene 'Elm Decline' and woodland clearance, and archaeological evidence Neolithic activity. This chapter will also consider the outcomes of the methodological approaches utilised in this thesis, while future research avenues are also outlined.

9.2. Relevance of this thesis and principal conclusions

This research has made a valuable contribution to the understanding of the nature of human-environment interactions during the Mesolithic/Neolithic transition (*c.*4500 – 3750 cal BC) by providing new insights into the chronological relationship between the archaeological evidence for Early Neolithic human activity and palynological 'events' often associated with such activity. This was achieved through the explicit use of the Bayesian approach which allowed for the quantitative integration and statistical assessment of the both datasets in a way which had not previously been undertaken in relation to the period. This has allowed for new determinations on the relationship between the palynological signal for the timing of ecological changes, such as the mid-Holocene 'Elm Decline' and woodland clearance, and the identified archaeological evidence for adoption of Neolithic practices to be made. The benefits of this approach were not limited to determining the relative order of different 'events' but enabled broader interpretations of the process of Neolithisation in the region to be evaluated.

Principal Conclusions

This thesis has demonstrated the prominent position of the rectangular timber house structure during this earliest Neolithic, demonstrating these to be among the earliest features of the period. The synchronous appearance of these structures across the region, in addition to the lack of a preceding parallel, certainly suggests that these represent the arrival of a new cultural phenomenon at the end of the 38th century cal BC.

However, this thesis has demonstrated that these were not the only manifestation of Early Neolithic settlement, with the occupation of more ephemeral site running parallel with the later phase of occupation at timber houses and continued when use of timber houses appears to have fallen out of practice. This indicates a degree of mobility existed in the period and settlement patterns represented a form of 'tethered mobility' (Whittle 1997). The continued use of ephemeral sites after the 'House Horizon' indicated a shift to a less well-defined and less sedentary lifeway in the post-'House Horizon' Neolithic.

The contemporary use of cave burials in the region with the court tomb tradition in the northern half of the island would indicate that cave burials represent a different, but broadly contemporary, funerary tradition in the region.

Both models (1 and 3) for the start of the Early Neolithic in the region indicate that it began quite rapidly, with occupation sites associated with Early Neolithic material appearing from *c.*3750 cal BC. The apparent swiftness of this appearance, in addition to the uniform nature of the material culture would appear to support the notion of colonists as the primary drivers of this new cultural phenomenon (cf. Sheridan 2003a; 2003b; 2004; 2010)

The early cattle bones from Ferriter's Cove and Kilgreany Cave remain somewhat of an enigma in the context of the Early Neolithic in the region. The dates for domesticates from Ferriter's Cove (*OxA-3869*) and Kilgreany Cave (*OxA-4269*) were demonstratively different from the wider set of dates for Early Neolithic activity elsewhere in the region. The implications of which were that either these represented outliers within the chronological sequence for the start of the Neolithic or that domesticates were introduced prior to the introduction of the remaining elements of the Neolithic 'package', namely cereal cultivation and house construction.

This thesis has also served to redress the geographical imbalance which had previously existed within palaeoenvironmental studies of the Late Mesolithic and Early

Neolithic period in Ireland. The two new palynological records which have been undertaken as part of this research have provided robust, well-dated profiles that have been highly informative of the changing mid-Holocene landscape in southern Ireland.

The comparison between the two sites has demonstrated the considerable degree of ecological variation which existed between the east and west of the region. Lough Cullin evidenced a local landscape dominated by a closed oak-elm deciduous woodland with an alder-willow carr woodland fringing the lake, while evidence for open habitats was restricted in the pre-'Elm Decline' landscape. At Arderrawinny, the local landscape was remarkable open in comparison, with pre-'Elm Decline' vegetation demonstrating strong evidence for open environments which was unusual, although not unique, in such contexts in Ireland.

The mid-Holocene 'Elm Decline' was exhibited at both sites, occurring at Lough Cullin from *4320 – 3990 cal BC*, and from *3890 – 3700 cal BC* at Arderrawinny. However, due to the nature of the local woodland composition this was far more pronounced at Lough Cullin than at Arderrawinny. The study exhibited little evidence that the mid-Holocene 'Elm Decline' in Ireland was a chronologically synchronous 'event' nor was any degree of geographical cohesion extrapolated for this on regional or island-wide scale.

The reliability of the 'Elm Decline' as a chronological proxy for the start of the 'Neolithic' was also questioned in this research. The integrated Bayesian analysis exhibited no correlation between the Early Neolithic archaeology of the region and the onset of the mid-Holocene 'Elm Decline' at either site. The interval between the 'Elm Decline' and the start of Early Neolithic houses, cereal cultivation etc. indicates that the onset of this 'event' at both sites was unconnected to Early Neolithic anthropogenic activity. However, a potential correlation between the 'Elm Decline' at Arderrawinny and the construction and use of the nearby portal tomb was suggested. It is therefore uncertain how reliable it is as a chronological proxy for the start of the Neolithic in Ireland.

However, a correlation between anthropogenic activity and the onset of the 'Elm Decline' can be suggested at several sites, although this need not necessarily be 'Neolithic' activity. If this correlation is accepted that this would indicate that the 'Elm Decline' at these sites was caused, either solely or in combination with other factors, by human activity at this time. However, this was not in general agreement across all sites which would therefore indicate that the 'Elm Decline' across the island was a complex, multifactor, site-specific process.

Following the 'Elm Decline a distinct *Landnam* phase is exhibited at Lough Cullin which involved sustained woodland clearance and farming activity over several centuries. The Bayesian comparison indicated that the *Landnam* phase occurred prior to the start of occupation at the Early Neolithic archaeological sites of the region and was therefore not related to Early Neolithic activity as defined by timber houses or cereal cultivation.

Whether this woodland clearance represents Mesolithic activity, the arrival of the Early Neolithic colonists, an additional 'failed colonisation' (Sheridan 2010) or the indigenous adoption of selective agricultural practices (Thomas 1988; 2004; 2013) is more difficult to decipher.

The potential that woodland clearance at Lough Cullin represented the effects of the utilisation of the lake for aquatic resources by Late Mesolithic communities cannot be discounted, as archaeological evidence for such activity is noted elsewhere (Woodman and Anderson 1990; Fredengren 2002; FitzGerald 2007; McQuade 2008). However, the *Landnam* exhibited at Lough Cullin appeared to have been restricted to trees growing on the drier mineral soils away from the lake edge. The lack of strong evidence for clearance of the alder-willow carr woodland would seriously question whether the phase of woodland clearance was related to access and the exploitation of lacustrine resources by Mesolithic hunter-gatherer groups.

The correlation between the cattle bone from Kilgreany Cave and the *Landnam* phase may indicate the presence of domesticates in the region at the time when the most intense phase of woodland clearance was occurring. Therefore, palynological evidence for open habitats near Lough Cullin may be as a result of some pre-'house horizon' Neolithic activity.

The domesticated cattle bone from Kilgreany Cave may be seen as representing a similar unsuccessful, pre-3750 cal BC 'failed colonisation' to that suggested at Ferriter's Cove (Sheridan 2003a; 2010; Tresset 2003). However, the woodland clearance exhibited at Lough Cullin was too intense and of too long a duration to represent an unsuccessful early migration of European Neolithic farmers. Additionally, this thesis and others (Cooney *et al.* 2011; Schulting 2014; McLaughlin *et al.* 2016) provided no evidence the appearance of the remaining elements of the Neolithic repertoire prior to the $39^{th}/38^{th}$

century cal BC and questions whether the *Landnam* at Lough Cullin was representative of either 'strand' of Neolithic colonisation as envisaged by Sheridan (2010).

Alternatively, this may represent the selective adoption facets of the Neolithic by Mesolithic groups resulting from an 'availability phase' (Zvelebil and Rowley-Conwy 1986), where farming and other aspects of the Neolithic 'package' become known to hunter-gather *via* exchange networks or social interactions. The stylistic variation of the Late Mesolithic lithics in Ireland may not represent a lack of social, cultural and economic interaction with continental European agricultural societies, and the possibility exists that Late Mesolithic groups in Ireland were aware of agricultural practises. Interactions between Late Mesolithic communities and early agriculturalists is evidenced elsewhere in northern Europe (e.g. Louwe Koojimans 2007; Vanmontfort 2007; Thorpe 2015), with hunter-gather groups selectively adopting otherwise Neolithic traits. Certainly, if the Late Mesolithic was not as insular as has been suggested then the correlation between the cattle bone from Kilgreany Cave and the intensive phase of woodland clearance at Lough Cullin, which predated the appearance of the 'House Horizon' and cereal cultivation, may relate to a gradual and selective adoption of animal husbandry by existing hunter-gatherer groups.

While the Neolithic communities represented in the archaeological record of the region played no role in the *Landnam* 'event' at Lough Cullin, continued evidence for open environments and agricultural activity following the end of the major clearance phase. The evidence for cereal cultivation recorded from *3820 – 3570 cal BC* occurred after the start of the Early Neolithic and after the start of cereal cultivation in the region, indicating that Early Neolithic arable activity was occurring near the lake.

However, the earliest palynological signal for cereal cultivation, recorded at *3920 – 3690 cal BC* occurred prior to the onset of the Early 'Neolithic'. This would have significant implications for the timing of the start of arable activity in the region, especially considering the lack of archaeological evidence for cereal cultivation in the region prior to *3750 – 3690 cal BC* or indeed across the island (cf. McClatchie *et al.* 2014) before *c.*3750 cal BC. This could support the notion of a more gradual transition to agriculture with certain Neolithic practices occurring prior to the 'House Horizon' in the region and what is deemed the Early 'Neolithic' may not be the first expression of agricultural practices.

At Arderrawinny evidence for post-'Elm Decline' anthropogenic activity was less conclusive. While a definitive Early Neolithic presence was evidenced in the form of a portal tomb, this was constructed within an already relatively open landscape. Increased open environments was evidenced following the start of the Early Neolithic in the region, however, this was on a scale which was similar to those that existed pre-'Elm Decline'. No conclusive evidence to suggest cereal cultivation or settlement in the area surrounding the megalithic tomb was provided, which may indicate that the landscape around Arderawinny was viewed as incompatible with such activity. The construction of a megalithic monument would have therefore provided an enduring symbol of an Early Neolithic community which existed within the wider landscape.

Conversely, the difficulty in detecting Early Neolithic activity may result from the fact that the local landscape of Arderrawinny remained quite open for much of the early and mid-Holocene, and as such, obscured the palynological signal for any early farming community which may have existed in the vicinity of the sampling site.

9.3. Reflections on the methodological approaches undertaken

This thesis has demonstrated the considerable benefits of adopting a Bayesian approach for the robust integration of archaeological and palaeoenvironmental data, specifically for the Mesolithic/Neolithic transition in Ireland. The nature of such a study necessitated that the chronology of the various records of past anthropogenic activity were precise and accurate if these were to be robustly integrated. For this reason, the Bayesian approach was employed as it permitted an increasing degree of sophistication in the production of archaeological and palaeoenvironmental chronologies. While this thesis was not the first to employ Bayesian statistical modelling to archaeological or palaeoenvironmental research in Ireland (e.g. McSparron 2008; Cooney *et al.* 2011; Whitehouse *et al.* 2014), it does represent the first such study to explicitly employ the Bayesian approach in the integration of these complementary proxies for past human activity.

The implementation of this approach has demonstrated how estimates for the timing of anthropogenic activity inferred from robustly-dated palynological profiles can be evaluated with those obtained from independently dated archaeological sites. The Bayesian approach has facilitated the interpretation of the palaeoenvironmental sequences themselves and through the integration of these with the archaeological record, determined whether specific palynological 'events' are chronologically associated with the archaeological 'events' of the period. However, the inherent benefits of such an approach is far more reaching than merely determining the statistically probable order of different 'events', the resulting chronological framework can be employed to inform broader archaeological and palaeoenvironmental interpretations. In particular, this thesis has demonstrated that such an approach allows for more robust statistical analyses of chronological records, which allowed for a broader understanding of the interrelationship between ecological and 'cultural' change.

Throughout this thesis the advantages of adopting such an approach have been thoroughly explored and elucidated, not merely in the integration of the archaeological and palaeoenvironmental records but in the evaluation of 'events' or features within these datasets. This approach has allowed for the degree of chronological asynchroneity of the mid-Holocene 'Elm Decline' to be established on both a regional and island-wide scale. However, it has also allowed for a far greater interrogation of this dataset, with the statistically probable order of this 'event' enabling a far greater understanding of the spatial cohesion or lack thereof, to be revealed. This thesis has also clearly demonstrated how the adoption of such a methodological approach can have considerable bearing on the understanding of anthropogenic activity across the Mesolithic/Neolithic transition, by demonstrating that the *Landnam* phase at Lough Cullin was in no way related to the recognised Early Neolithic activity in the region, which has considerable implications on the understanding of the process of Neolithisation.

However, while the application of the Bayesian approach has greatly enhanced the understanding of the interrelationship between the palaeoenvironmental and archaeological records during this period, certain inherent problems were also evidenced. Firstly, the need for precise Bayesian frameworks to be established resulted in the exclusion of numerous sites form the investigation. Secondly, the resolution of the radiocarbon records from certain sites resulted in *P_Sequence* model in which the *posterior density estimates* for 'events' were too wide to be of use in a study of this kind. The necessity of robust and precise chronological records resulted the exclusion of all *PDE* ranges which were greater than 600 years. This therefore reduced the available dataset to less than forty sites.

This thesis has therefore demonstrated the need for palaeoenvironmental researchers to give greater considerations as to how the chronological framework of these investigations are approached. While financial constraints will undoubtedly continue to be a factor in such works, the necessity for increased chronological resolution must be advocated (cf. Blaauw *et al.* 2018). The resolution of radiocarbon dates within a profile must be sufficient to ensure that the resulting chronological models are precise and accurate. While the effectiveness of palaeoenvironmental analysis has been greatly enhanced over the past several decades, by increased considerations of quantitative approaches to landscape reconstruction (e.g. Bunting *et al.* 2005; Gaillard *et al.* 2008; Mitchell 2011), the same degree of consideration has not been forthcoming in relation to chronology. In essence, as a discipline paleoecology must strive to improve how it approaches the chronology of its work, with a greater appreciation given to not just the number of radiocarbon dates obtained but also the resolution of the these across the entire sedimentary core.

9.4. Future research

This study primarily focused on the nature of human-environment interactions during the Mesolithic/Neolithic transition (*c.*4500 – 3750 cal BC) by applying a Bayesian approach to the integration of the archaeological evidence for Early Neolithic human activity and palynological 'events' often associated with such activity. While this thesis has provided new and constructive insights into understanding this process, it has also elucidated further aspects which need to be addressed:

1. The results of the paleoenvironmental analysis undertaken as part of this research have provided useful insights in the vegetation history of the region during the Mesolithic and Neolithic periods. However, while this analyses has proved invaluable to the understanding of human-environment interactions, these would benefit considerably with the application of quantitative approaches to landscape reconstruction (e.g. HUMPOL Bunting *et al.* 2005). The application of which would estimate in more quantitative terms the likely extent and nature of landscape change at what was a pivotal period for the evolution of culturally influenced landscapes.
2. While the results of the integrated Bayesian analysis of the combined palaeoenvironmental and archaeological records has provided interesting insights into the timing and cause of the earliest anthropogenic activity in the region, the

lack of a similar comparable site to Lough Cullin has restricted the scope of this interpretation to the local landscape. The interpretations outlined in this thesis would be greatly enhanced by comparison to a similar well-dated site elsewhere.

3. A major finding of this thesis has been the understandings gleaned in relation to the palaeoenvironment of portal tomb construction at Arderrawinny, in addition to the chronological relationship between this and the onset of the 'Elm Decline'. However, this interpretation is hypothesised on the basis of the tomb being broadly contemporary to the excavated example at Poulnabrone, County Clare. This interpretation would therefore greatly benefit from an independent assessment of the date for construction and use of the portal tomb at Arderrawinny. Additionally, to determine how representative the palaeoenvironment of this tomb is of general tomb construction this interpretation would benefit from further palaeoenvironmental investigations of similar landscapes.
4. A final element of this thesis which needs to be addressed in further detail is whether the inclusion of additional environmental or edaphic parameters could elucidate some form of pattern from the chronologically asynchronous 'Elm Decline' across the island. While this thesis has demonstrated that no coherent spatial pattern was evident for this 'event', the potential exist that this could be elucidated in relation to underlying geology or prominent soil the region.

9.5. Concluding remarks

Through the explicit implementation of the Bayesian approach to the integration of palaeoenvironmental and archaeological records this study has provided new insights into the forager to farmer interface in southern Ireland. This thesis has demonstrated a clear chronological separation between the earliest palynological evidence for anthropogenic activity and the archaeological evidence for the start of the Neolithic in the region. The broader implication of this study are that the process of Neolithisation in the region may have been more gradual than suggested by the archaeological evidence for the arrival of Neolithic practices.

The Mesolithic/Neolithic Transition in the Southern Region of Ireland:

A Bayesian Approach to the Integration of the Palaeoenvironmental and Archaeological Records.

Appendices

Appendix A - Laboratory procedures

A.1. Pollen

Samples (one cm3) were taken from the cores for pollen analysis by volumetric displacement and processed using standard procedures (Moore *et al.* 1991). Samples were transferred to labelled 50ml polyethylene centrifuge tubes. *Lycopodium clavatum* spores were added to the samples before treatment (Stockmarr 1971) to allow for the calculation of pollen concentration. 10ml of 10% hydrochloric acid (HCl) solution was added to each. Samples were then placed in a boiling water bath for 20 minutes or until effervescence stopped, this removed all calcium carbonate (CaCO3), to prevent the formation of insoluble calcium fluoride (CaF2) at a later stage of the procedure. 2ml of methanol (CH3OH) was added to each sample to reduce specific gravity. Samples were centrifuged at 3600 RPM for 5 minutes and decanted. Samples were then washed twice with deionised water, with 2ml of methanol added each time, centrifuged and decanted.

10ml of 10% sodium hydroxide (NaOH) solution was added to each sample and place in a boiling water bath for 2-3 minutes to remove humic acid. The darkness of the supernatant was recorded as a measure of the degree of humification of each sample. The samples were then sieved through a 60 µm mesh screen to remove coarse mineral material and organic debris. The residue on the screen was washed thoroughly into 50ml centrifuge tubes with a jet of deionised water, 2ml of methanol was added, samples were centrifuged and decanted. The course material was retained in labelled vial for examination with a binocular microscope for macrofossil analysis. Each sample was washed for at least a further five times with deionised water, 2ml of methanol and centrifuged until no trace of brown colour remained in the supernatant. When washing each sample was stirred gently to prevent the formation of lumps.

Once the samples had been washed enough for the supernatant to run clear, each sample was placed on a microscope slide and inspected under a microscope. If inorganic material remained in the sample, then each sample was transferred to a labelled HF tubes (50ml polyethylene centrifuge tube with cap). Each sample was then washed with 10ml of 10% hydrochloric acid (HCl) to remove any remaining calcium carbonate (CaCO3), centrifuged and decanted. Hydrofluoric acid (HF) treatment was then conducted to remove inorganic material, if necessary.

In a HF fume cupboard, 10ml of 60% hydrofluoric acid (HF) was added to each sample. Samples were then placed in a boiling water bath for 25-30 minutes. Samples were stirred every 5 minutes using a polyethylene rod. Once complete each tube was filled with methanol, to reduce specific gravity, centrifuged and decanted into a Calcium Carbonate ($CaCO_3$) solution, within the fume cupboard. When all the hydrofluoric acid was decanted, 10ml of 10% hydrochloric acid (HCl) was added to each sample and placed in a boiling water bath for 20 minutes to remove colloidal silicates and silicofluorides. 2ml of methanol was added, the samples were centrifuged and decanted.

The samples were then washed with deionised water, 2ml of methanol, centrifuged and decanted. Acetolysis digestion was then applied to remove non-pollen organics. Each sample was washed in glacial acetic acid (CH_3COOH) to remove water from the samples, centrifuged and decanted. This step was repeated to ensure that all water content was removed as the acetolysis solution reacts violently with water. Once water removal was complete, a solution of 9ml acetic anhydride [$(CH_3CO)_2O$] or (Ac_2O) and 1ml concentrated sulphuric acid (H_2SO_4) was added to each sample. Samples were then placed in a boiling water bath for 2 minutes and stirred after 1 minute. Once removed from the water bath, each tube was half filled with glacial acetic acid (CH_3COOH), centrifuged and decanted. 10 ml of glacial acetic acid (CH_3COOH) was added to each sample, centrifuged and decanted to remove the soluble cellulose acetate products of acetolysis.

Samples were then washed in deionised water and 2 ml of methanol, centrifuged and decanted. Deionised water and a few drops of 10% sodium hydroxide (NaOH) was added to each sample until the correct pH (*c.*7) was obtained for staining. Samples were then centrifuged and decanted. 1 drop of aqueous safranin and 50ml of deionised water was added to each tube to stain the samples to aid identification of microfossils. Samples were centrifuged and decanted. 10ml of tertiary butyl alcohol (TBA) or 2-methylpropan-2-ol (2M2P), was added to each sample, centrifuged and decanted. Sediments were then washed into labelled vials with a minimal amount of tertiary butyl alcohol (TBA). Silicone oil of 2000 viscosity was added to each sample in equal amount to the remaining sediment and left uncorked for 24 hours for the tertiary butyl alcohol (TBA) to evaporate off. Once the residual tertiary butyl alcohol (TBA) was evaporated, slides were prepared by placing small drops of the residue in the centre of labelled microscope slides and covered with a coverslip.

A.2. Loss on Ignition

Place some sample (*c.*5 cc) in each crucible and weigh. This is your wet weight. Dry the sediment samples at 105 °C overnight or for at least 12 hours in the drying oven. This will evaporate water, and the resulting weight will be your 100°C weight. Turn off the oven and let samples cool (until <30°C), before removing and weighing. If samples cannot weigh the immediately after they cool, place in a desiccator until they can weigh them. After weighing and recording your 100°C weight, return the samples to the furnace for a 4 -hour burn at 550°C. This will burn off organic matter. After 4 hours switch off the furnace and allow it to cool down. Using tongs and heat resistant gloves place the slightly cooled crucible in the desiccator and allow to cool to room temperature. Once cooled re-weigh and record weight. This can be used to calculate the percentage of organic content by using the following formula; % LOI = oven dry weight (mg) - ignited weight (mg) x 100/ oven dry weight (mg) (Heiri *et al.* 2001).

Appendix B - Early Neolithic Archaeological sites

(1) Townland: Ahaglisin

Barony: Ibane

County: Cork

Site Type: Portal Tomb

SMR: CO016-226001-

Excavation Licence Number: N/A

ITM: 530666, 536340

National Grid: 130701, 36269

OD: 50-100m

Reference: (De Valera and Ó Nualláin 1982, 37-38, Co.55; Roberts 1988, Ch1, No.55; Power *et al.* 1992)

This monument is located *c.*2.4 km east of Rosscarbery and *c.*1 km north of Rosscarbery Bay, situated on a small platform, near the top of a steep hillside, overlooking valley of Ownahinchy River. The entrance to chamber is at the east, marked by two portal-stones, set *c.*0.7m apart. The northern portal-stone is erect and measures *c.*1.60m long by *c.*1.80m high and is *c.*0.30m thick. The southern portal-stone leans against the northern portal-stone and measures *c.*1.40m long by *c.*1.85m high (if erect) and is *c.*0.25m thick. An orthostat, measuring *c.*1.35m long by *c.*0.90m high and *c.*0.20m thick runs eastwards from the northern portal-stone while an orthostat, measuring *c.*0.90m long by *c.*1.00m high and *c.*0.15m thick runs eastward from the southern portal-stone. Two slabs lean against southern side of chamber, three small stones lean against northern portal-stone, the function of which is unclear. In front of each portal-stone, the orthostats form the inner end of funnel-shaped approach to the tomb entrance. The line of southern orthostats continue for *c.*2.5m to the east by two pairs of overlapping slabs. The back-stone is located at the western end of the tomb and measures *c.*1.80m long by *c.*1.00m high and is *c.*0.35m thick. The chamber is covered by a high-pitched roof-stone resting on the portal-stones and two large pad-stones. The roof-stone measures *c.*3.75m long by *c.*2.20m wide and is *c.*0.60m thick. The pad-stones are located in both the north-western and south-western corners of the tomb and measure *c.*1.10m by *c.*0.90m by *c.*0.15m thick (NE corner) and *c.*1.00 by *c.*0.70m by *c.*0.10m thick. The has not been excavated.

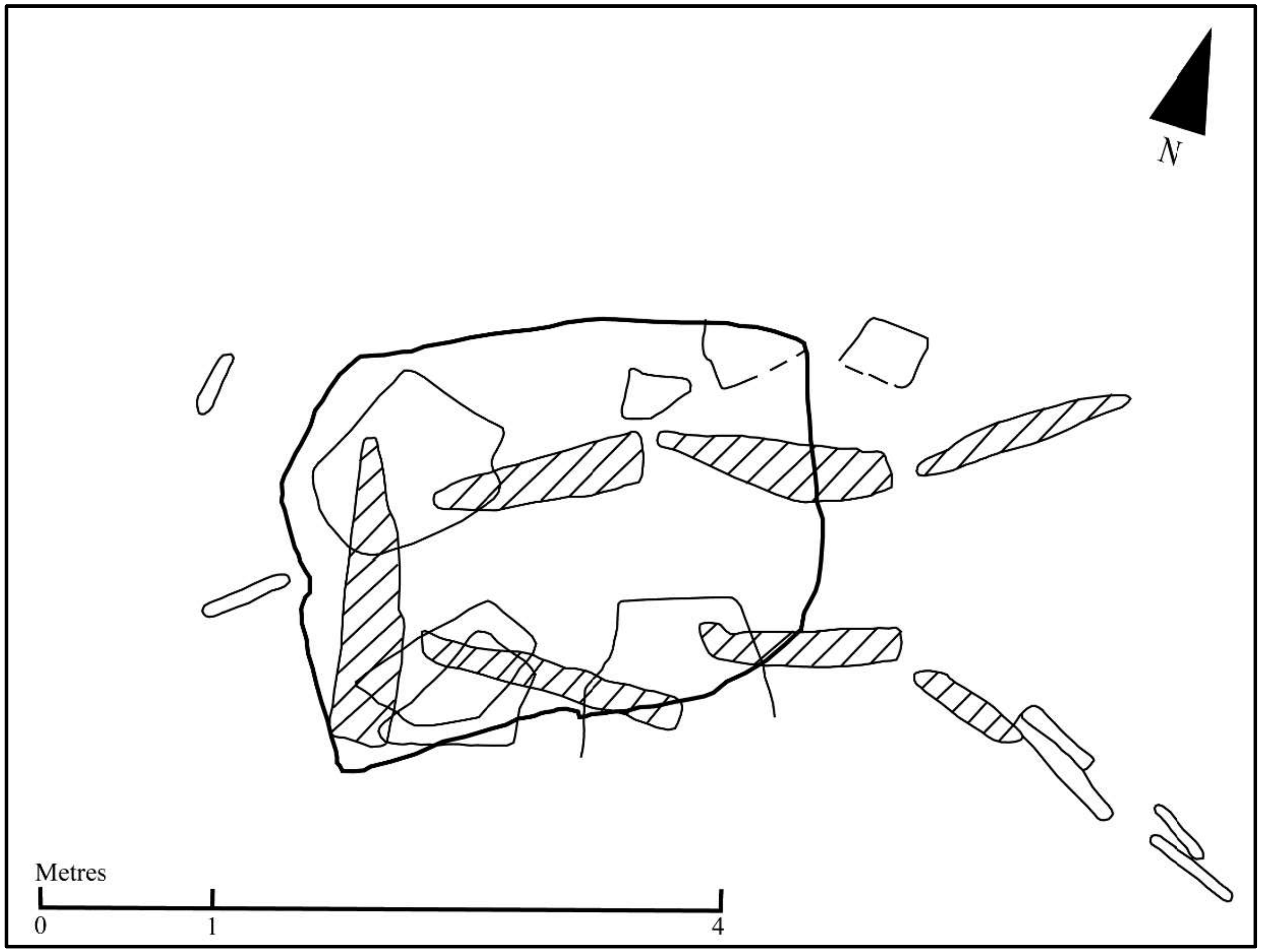

Figure B.1Ahaglisin Portal Tomb in plan, after de Valera & Ó'Nualláin (1992)

(2) Townland: Annagh

Barony: Owneybeg

County: Limerick

Site Type: Burial

SMR: LI006-079001-

Excavation Licence Number: 92E047

ITM: 569366, 658426

National Grid: 169408, 158382

OD: 50-60m

Reference: (Ó Floinn 1992; 2011; Dowd 2008; Ó Donnabháin 2011)

The site is located in the townland of Annagh, approximately 15km north-east of Limerick City, close to the Tipperary border. The site was discovered in 1992 prior to blasting at a limestone quarry and was excavated in March and May 1992 by Raghnall Ó Floinn of the National Museum of Ireland. The site consisted of an oval chamber *c.*4.50m long by *c.*2.50m wide. The entrance had been sealed by a pillar-like slab measuring 1.02m long by 0.38m wide and 0.22m in thickness. The floor of the chamber sloped from east to west so that the eastern end was obscured. The deepest part of the chamber was at its western end, measuring *c.*1.00m in height, and it was here that the principal burials occurred. Excavation concentrated on the cave fill immediately below the area where the human bone was found. This consisted of an L-shaped area along the south and west sides of the cavern. The fill of the cave was a uniform dark brown loamy clay with stones of varying size up to 0.7m in length. In total, three human burials were recovered and portions of at least two others. Animal bone was also noted resting on loose stones, which were covered in limewash. Associated with the burials were two complete vessels, substantial portions of third vessel and fragments of a fourth undecorated vessel. Artefacts not directly associated with the burials were also noted, including flint blades, flint arrowheads and some further sherds of pottery, probably from the same carinated undecorated vessel found with the burials.

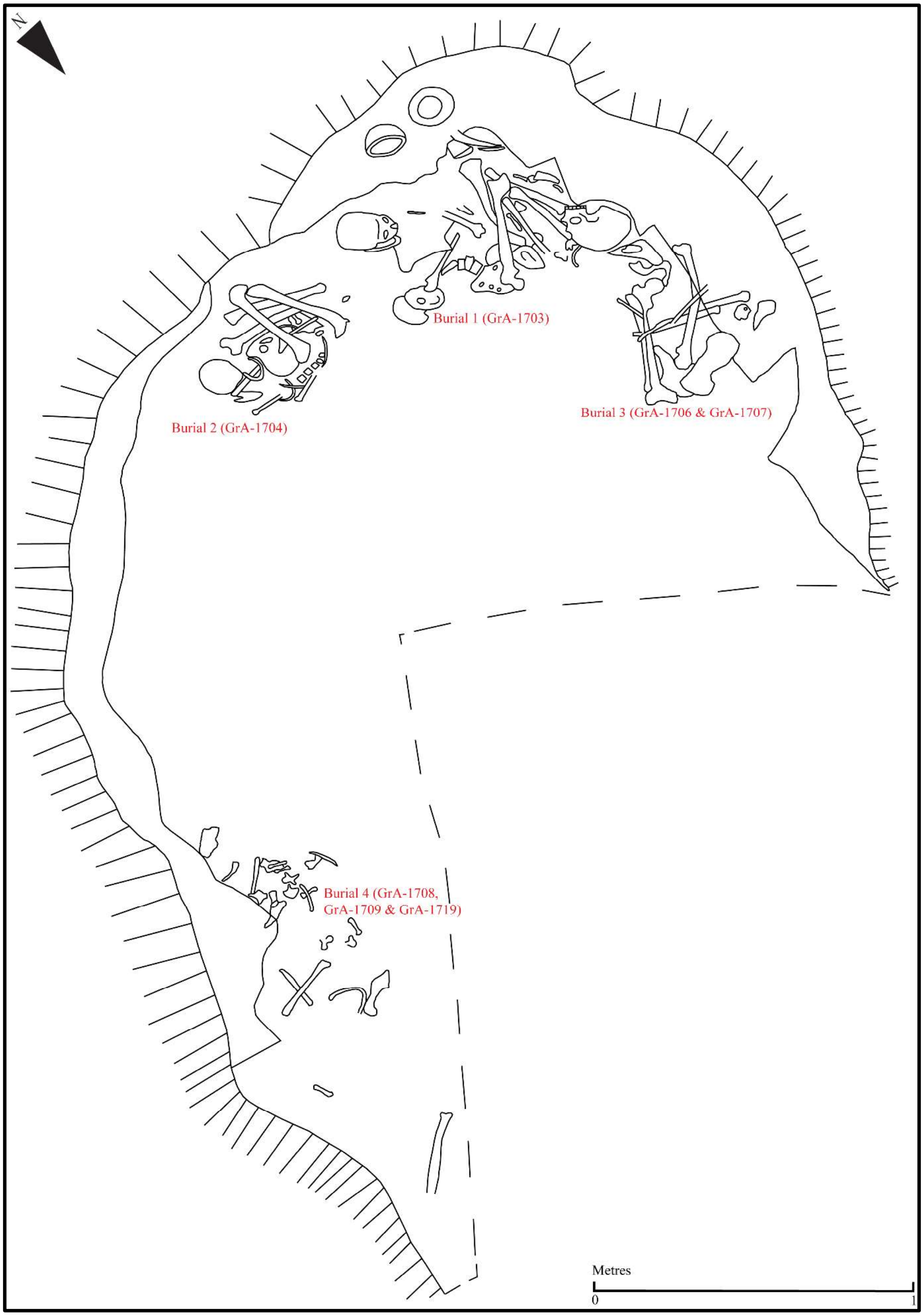

Figure B.2 Excavation of burials at Annagh Cave in plan

Burial 1

Burial 1 was located at the western end of the chamber between burials 2 and 3. The remains were those of an adult male aged 55+ years at the time of death. The burial consisted of a crouched inhumation lying on its left side. A bone point (possibly sheep) was found underneath the left arm. Sherds of a decorated bowl (vessel 3) was found underneath the body, several fragments of a plain carinated vessel (vessel 4) were also associated with this burial. Two pottery vessels (vessels 1 and 2), in addition to burnt sheep bone and a cow's tooth were found on a ledge above burial 1. Fragments of sheep bone were also identified among the remains of burial 1.

Burial 2

Burial 2 was located south of burial 1. It consisted of the crouched, articulated remains of an adult male aged 55+ at the time of burial. A discoidal flint knife was found at the base of the spine. A large sherd of a plain carinated vessel (vessel 4) rested at the base of the skull while another sherd of the same vessel was found in the area of the torso. Animal bones of pig and hare were found in associated with this burial.

Burial 3

Burial 3 consisted of the disarticulated skeletal remains of an adult male aged at least 30 at the time of death and was located north of burial 1. The placement of the bone suggest that this burial was a secondary deposition within the cave. A flint flake and stone pebble were below the northern and eastern end of the skull. The remains of pig, sheep, cow, bear and possible wolf were identified with burial 3.

Burial 4

This consisted of the disarticulated remains of two individuals, probably male, together with a number of animal bones. The remains consisted of various small bones with no evidence of skulls or long bones. Small sherds of coarse undecorated pottery (similar to those with burial 2) were found intermixed with these remains. The remains of pig, hare, bear and sheep were also identified with this deposit. Two pieces of burnt bone, possibly human, were also recovered along the southern wall beside burial 4. Additionally, some blackened human bone was recovered on the ledge at the western end of the cave between vessels 1 and 2.

Ceramics

Two complete vessels and fragments of two others were recovered during excavation. Vessel 1 is an almost complete vessel of classic Style 1 Necked Vessel A type (Herity 1982, 268-269). Vessel 2 is a complete globular bowl of the type referred to as Goodland bowls (Herity 1982, 275). Both vessel 1 and 2 were recovered from a ledge above burial 1. Vessel 3 was also found in association with burial 1 and consisted of a number of sherds of globular bowls similar to one of the Rockbarton (Cahirguillamore), Co. Limerick vessels (Herity 1982, 311). Vessel 4 consists of fragments of a plain shouldered bowl. Vessel 4 was recovered from various parts of the cave in association with burials 1, 2 and 4.

Lithics

The lithic assemblage consisted of a leaf-shaped, heavily patinated flint arrowhead with a slight tang, an unretouched heavily patinated flint blade, a narrow, unretouched pointed flint flake which were recovered scattered throughout the cave. A heavily patinated flint artefact of semi-circular form, which may form a discoidal knife was recovered under the lumber vertebrae of burial 2.

Radiocarbon dating

Seven radiocarbon dates from human (five) and animal (two) were obtained for the site (see Table B.1). The dates, with the exception of *GrA-1719* (bear radius), show a reasonably tight group with suggests the cave was used for burials on a single occasion or over a reasonably short time period.

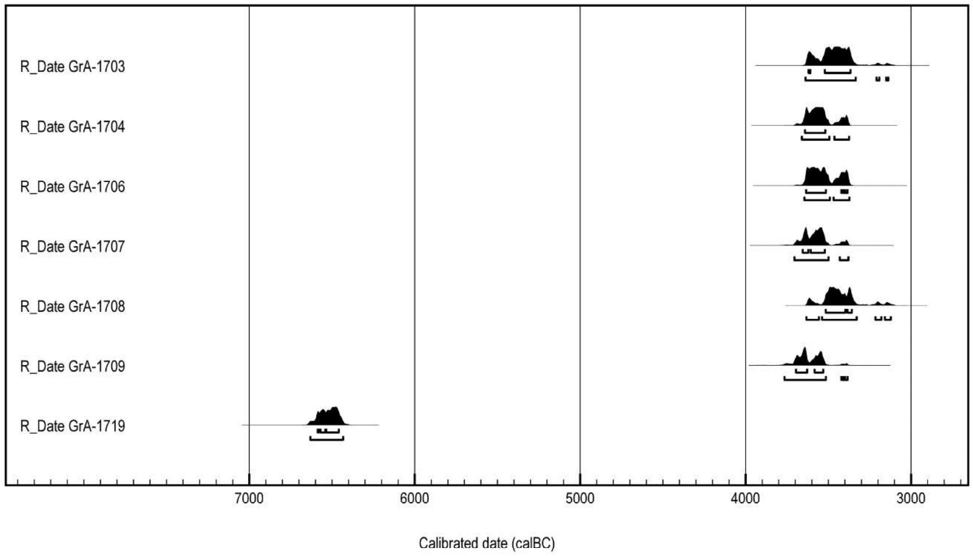

Figure B.3 Calibrated radiocarbon dates for burials at Annagh Cave

Lab Code	Context	Dated Material	Radiocarbon Age (years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
GrA-1703	Burial1	Right scapula	4670±70	3639-3336 cal BC (93.8%) 3210-3192 cal BC (1.0%) 3151-3138 cal BC (0.7%)	3620-3610 cal BC (3.3%) 3522-3367 cal BC (64.9%)
GrA-1704	Burial 2	Right scapula	4780±60	3660-3494 cal BC (77.1%) 3464-3375 cal BC (18.3%)	3642-3519 cal BC
GrA-1706	Burial 3	Sheep humerus	4750±60	3645-3492 cal BC (67%) 3469-3373 cal BC (28.4%)	3635-3516 cal BC (60%) 3422-3419 cal BC (1%) 3409-3405 cal BC (1.4%) 3398-3385 cal BC (5.8%)
GrA-1707	Burial 3	Right scapula	4810±60	3706-3500 cal BC (87.2%) 3432-3379 cal BC (8.2%)	3655-3621 cal BC (19.0%) 3607-3522 cal BC (49.2%)
GrA-1708	Burial 4	Right scapula	4640±60	3633-3558 cal BC (9.2%) 3538-3329 cal BC (80.8%) 3216-3180 cal BC (2.9%) 3158-3123 cal BC (2.6%)	3516-3397 cal BC (55.8%) 3385-3358 cal BC (12.4%)
GrA-1709	Burial 4	Right scapula	4840±60	3766-3515 cal BC (93.5%) 3422-3419 cal BC (0.2%) 3410-3404 cal BC (0.4%) 3398-3384 cal BC (1.3%)	3696-3628 cal BC (39.8%) 3584-3532 cal BC (28.4%)
GrA-1719	Burial 4	Bear radius	7670±60	6632-6433 cal BC	6587-6582 cal BC (2.9%) 6571-6541 cal BC (17.4%) 6535-6460 cal BC (48%)

Table B.1 Calibrated radiocarbon dates for burials at Annagh Cave

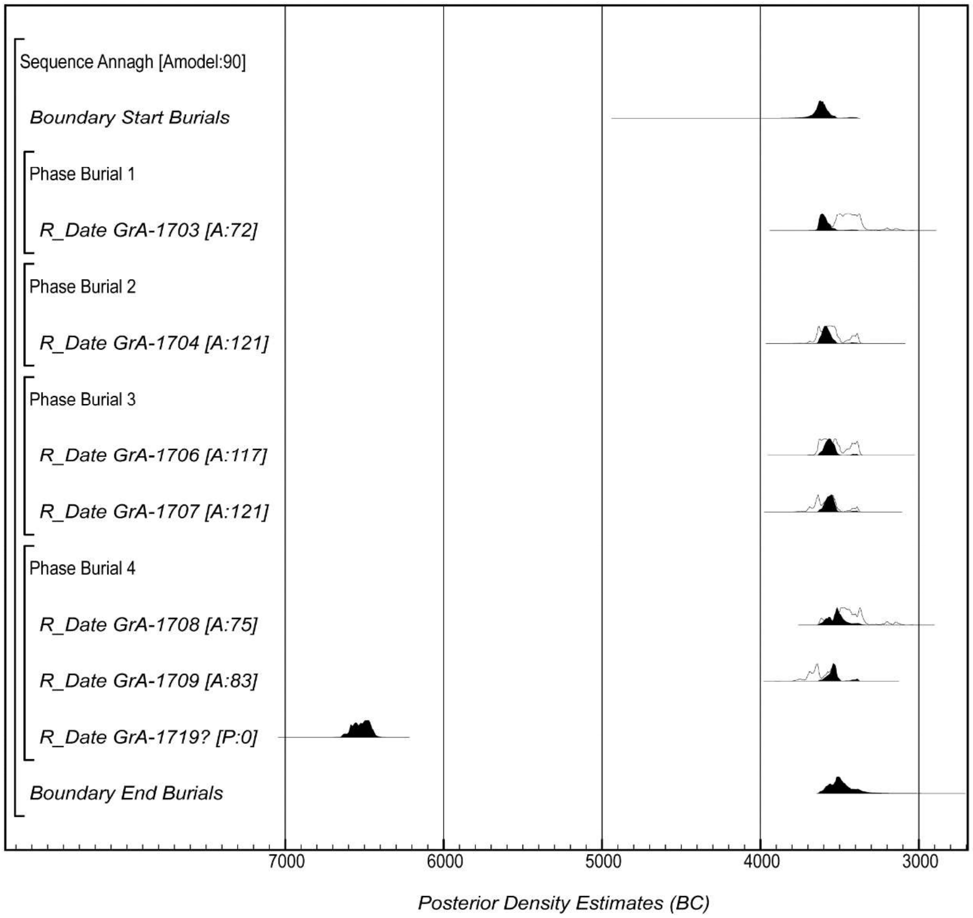

Figure B.4 Bayesian model for burials at Annagh Cave

Six radiocarbon dates, *GrA-1703*, from burial 1, *GrA-1704* from burial 2, *GrA-1706* and *GrA-1707,* the two statistically consistent (T'=0.5; T'(5%)=3.8; v=1) (Ward and Wilson 1978) dates from burial 3 and *GrA-1708* and *GrA-1709* from two separate individuals in the disarticulated burial 4 were included in the Bayesian model for burial activity at Annagh. *GrA-1719* was much earlier than the others and was therefore excluded from the model. These six dates were plotted using OxCal 4.2.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the burial activity at Annagh cave. Bayesian modelling returned a date range of *3750-3410 cal BC (95% probability), 3660-3570 cal BC (68% probability)* for the start of burial activity at Annagh cave, and a date range of *3590-3340 cal BC (95% probability), 3590- 3450 cal BC (68% probability)* for the end of burial activity ($A_{overall}$=89.3). The model also proposed a duration of burial activity at Annagh cave of between *0-330 years (95% probability), 0-160 years (68% probability)*.

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 89.5 Aoverall 89.3		
	from	To	%	from	To	%	from	to	%	from	to	%	Acomb	A	C
Sequence Annagh															
Boundary Start Burial							-3651	-3573	68.2	-3741	-3416	95.4			98.5
Phase Burial 1															
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3631	-3581	68.2	-3646	-3524	95.4		71.8	99.7
Phase Burial 2															
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3614	-3559	68.2	-3638	-3523	95.4		121.1	99.8
Phase Burial 3															
R_Date GrA-1706	-3635	-3385	68.2	-3645	-3373	95.4	-3595	-3534	68.2	-3634	-3391	95.4		116.7	99.7
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3590	-3535	68.2	-3634	-3514	95.4		121.1	99.7
Phase Burial 4															
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3592	-3478	68.2	-3624	-3379	95.4		74.3	99.1
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3577	-3517	68.2	-3622	-3382	95.4		83.1	99.7
R_Date GrA-1719	-6587	-6460	68.3	-6632	-6433	95.4	-6587	-6460	68.2	-6632	-6434	95.4			99.4
Span Duration of Burial							0	154	68.2	0	322	95.4			96.5
Boundary End Burial							-3586	-3453	68.2	-3624	-3345	95.4			97

Table B.2 Bayesian model of burials at Annagh Cave

(3) Townland: Arderrawinny

Barony: West Carbery

County: Cork

Site Type: Portal Tomb

SMR: CO148-011----

Excavation Licence Number: N/A

ITM: 487467, 530781

National Grid: 87493, 30709

OD: 100-200m

Reference: (De Valera and Ó Nualláin 1982, 41-42; Ó Nualláin 1983, 92; Roberts 1988, Ch.4, No.18; Power *et al.* 1992, 14; O'Brien 1999, 73-74)

This monument is situated *c.*150m north of the Skull-Crook Haven road. It is located on a small patch of grassland at the foot of a cliff. The tomb is orientated north-west into the cliff but with limited outlook towards the sea to the south. The tomb is in a good state of preservation thought it is tilted to the south. It consists of a narrow chamber with two overlying roof-stones, with the entrance to the north-west. The structure is incorporated into a low oval-shaped mount measuring *c.*10.00m by *c.*8.00m rising to a height on *c.*0.75m. The southern portal-stone is set inside the end of the adjoining side-stone and stands in from of the door, it measures *c.*0.80m long, narrowing to *c.*0.30m at the base, by *c.*1.85m high and *c.*0.20m thick. The northern portal-stone is *c.*1.25m long by *c.*1.50m high and *c.*0.25m thick. The door-stone is *c.*0.55m long by *c.*1.50m high and is *c.*0.15m in thickness. The southern side-stone is *c.*2.85m long by *c.*1.45m high and *c.*0.30m thick, the opposite side-stone is pitched heavily to the south and extends beyond the portal to the west. If upright, it would be *c.*2.20m long by *c.*1.00m high and *c.*0.20m thick. The back-stone at the western end of the chamber is rather low and largely concealed, it is *c.*1.35m long by *c.*0.40m high and *c.*0.40m thick. The western roof-stone rests on both portal-stones and the southern side-stone, it measures *c.*3.30m long by *c.*2.30m wide and is *c.*0.35m in thickness. The second roof-stone rests on both side-stones and the back-stone, it measures *c.*2.80m long by *c.*1.45m wide and is *c.*0.30m thick. This monument has not been excavated.

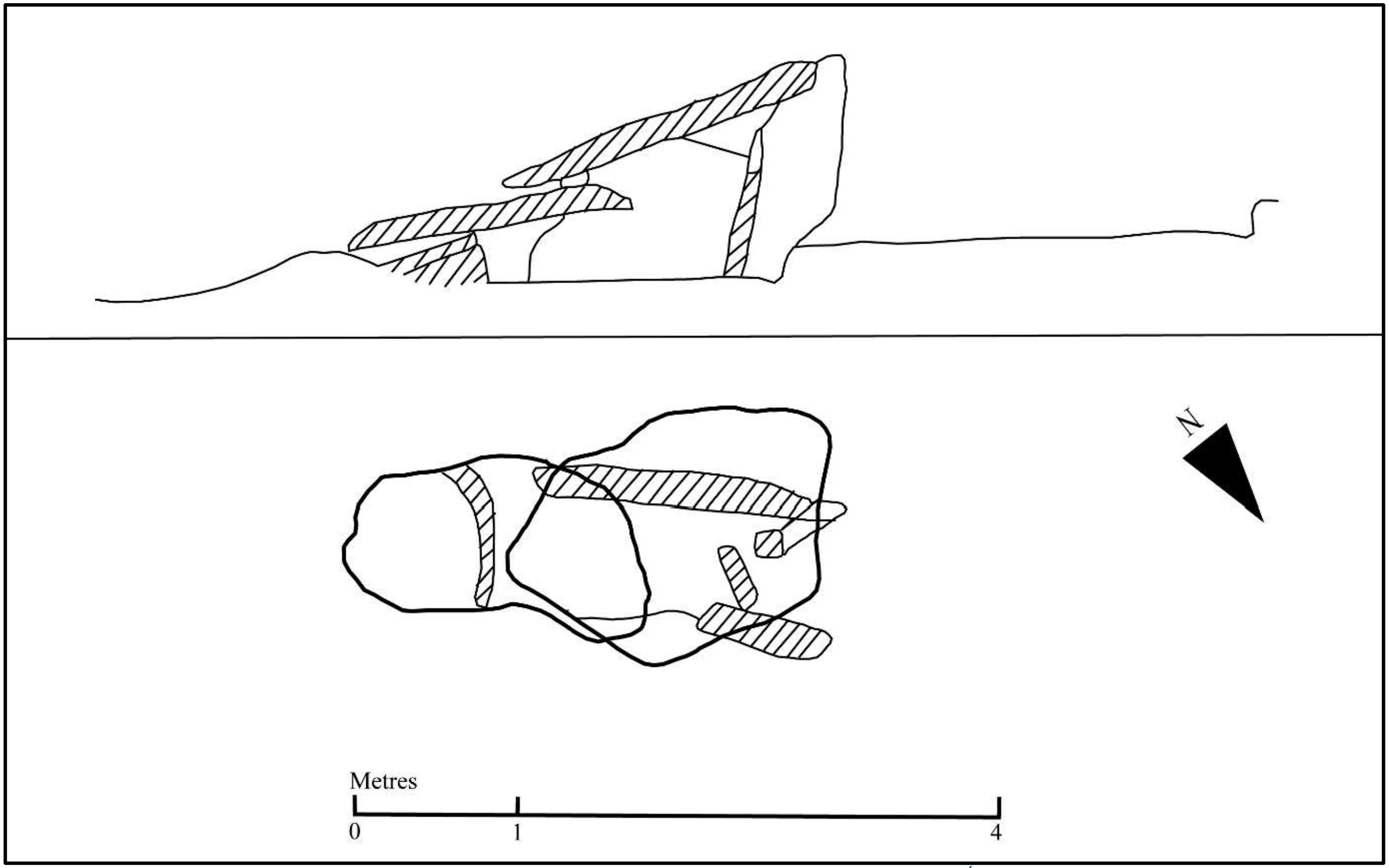

Figure B.5Arderrawinny Portal Tomb in section and plan, after de Valera & Ó'Nualláin (1992)

(4) Townland: Baile na Móna Íochtarach/Ballynamona Lower

Barony: Na Déise laistigh den Drom/Decies without Drum

County: Port Láirge/Waterford

Site Type: Court Tomb

SMR: WA039-007----

Excavation Licence Number: N/A

ITM: 628700, 583623

National Grid: 228755, 83563

OD: 100-200m

Reference: (Powell 1938; Moore 1999, 1-2)

The site is located in rough pasture on top of a small headland, with sea-cliffs *c.*70m to the east and *c.*180m to the south. The gallery, measuring *c.*3.95m in length, consists of two chambers with two portal-stones and a septal-stone opening to the west where there is a court, measuring *c.*5.5m in width represented by four stones. The site was excavated in May 1938 by T.G.E. Powell.

Ceramics

The ceramic assemblage consisted of 11 fragments of a least 2 vessels, one of which was decorated. The pottery fragments are suggested to be from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

The lithic assemblage consisted of three pieces of very worn, worked flint, two of which may have been used as hollow scrapers. Also recovered was a small stone disk of Old Red Sandstone.

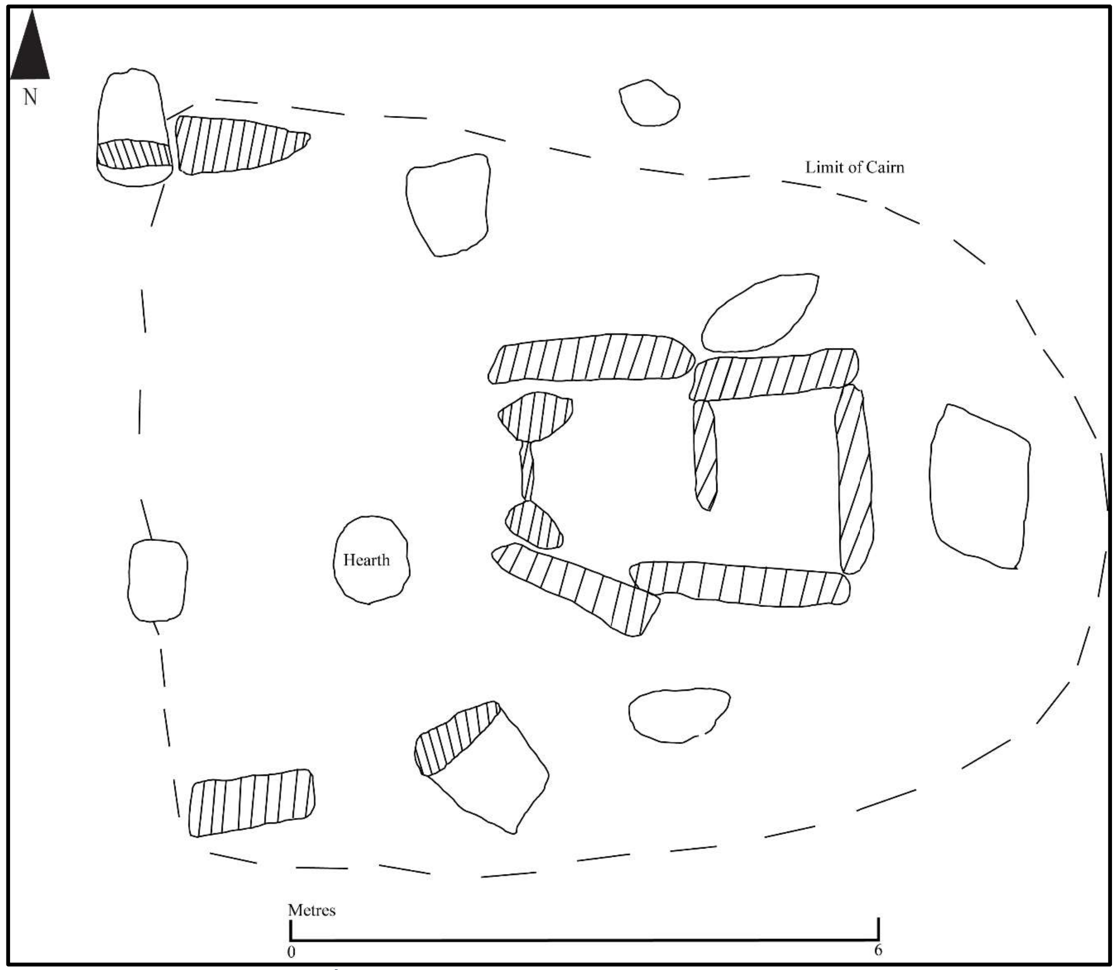

Figure B.6 Baile na Móna Íochtarach/Ballynamona Lower Court Tomb in plan, after Powell (1938)

(5) Townland: Ballinaspig More (Site 4)
Barony: Cork
County: Cork
Site Type: Pit
SMR: CO073-113----
Excavation Licence Number: 02E0947
ITM: 562879, 569054
National Grid: 162921, 068992
OD:
Reference: (Danaher and Cagney 2004c; Hanley and Hurley 2013)

The site was identified in advance of roadworks on the N22 Ballincollig bypass and was fully excavated in April 2002. A single pit, C.03, and the adjacent remains of two truncated post-holes represented Neolithic activity at the eastern extremity of the site. Pit C.03 yielded two sherds of prehistoric pottery and occasional fragments of cremated bone. This was a shallow pit located *c*.1.5m north of post-hole C.05 and 2.3m south of post-hole C.08. Post-hole C.05 also contained two similar sherds of pottery. Post-hole C.08 was located *c*.2.3m north of pit C.03 and contained a heavily-burnt deposit at its centre which was visible in section and may have been the remains of a post burnt *in situ.*

Ceramics

Four sherds of pottery were recovered; two from C.3 and two from C.5. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Radiocarbon dating

A single radiocarbon date was obtained from the excavation at Ballinaspig More (site 4) (see Table B.3). Alder charcoal from fill C.02 of pit C.03 returned an Early Neolithic date range of 3960-3712 cal BC.

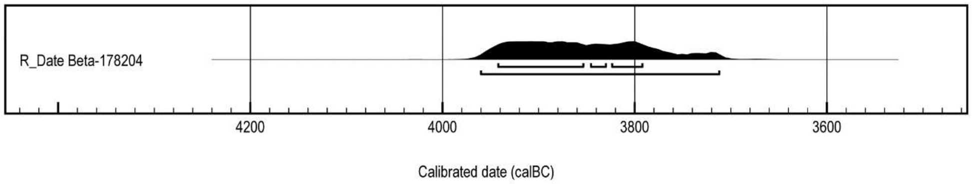

Figure B.7 Calibrated radiocarbon date from Ballinaspig More site 4

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
Beta - 178204	C.03	Alder Charcoal	5050 ± 50	3960-3712 cal BC (95.4%)	3942-3854 cal BC (45.6%) 3846-3830 cal BC (7.0%) 3824-3792 cal BC (15.5%)

Table B.3 Calibrated radiocarbon date from Ballinaspig More site 4

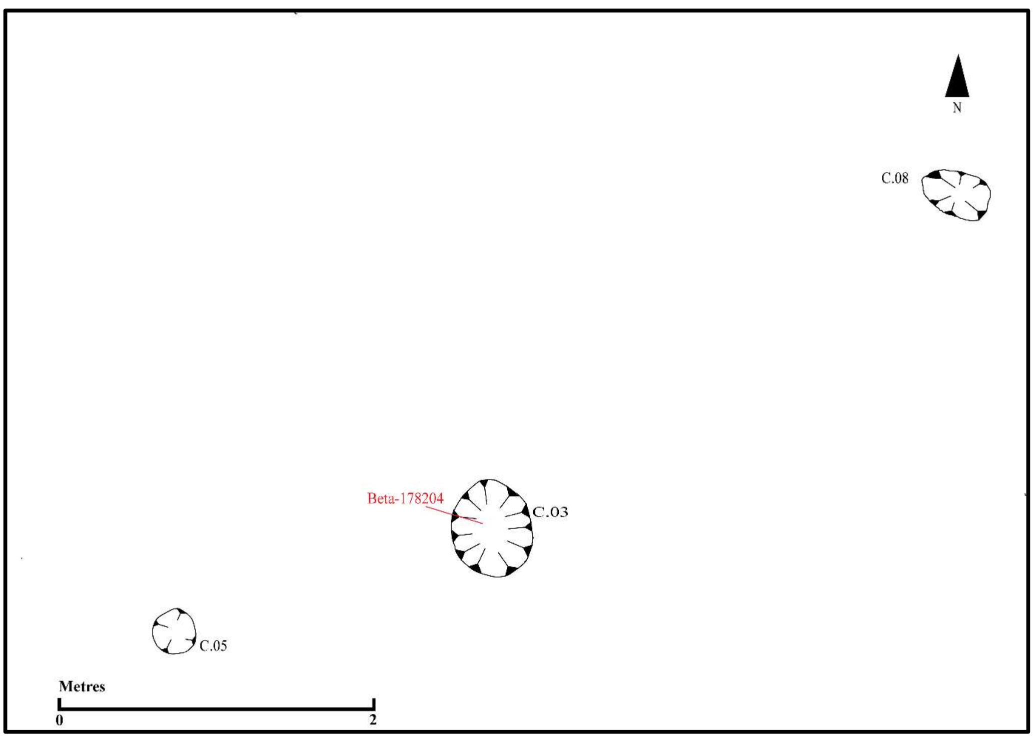

Figure B.8 Early Neolithic pit at Ballinaspig More (site 4)

(6) Townland: Ballinaspig More (Site 5)

Barony: Cork

County: Cork

Site Type: Pits, post-holes, stake-holes and hearth

SMR: N/A

Excavation Licence Number: 02E1033

ITM: 562879, 569054

National Grid: 162860, 069150

OD:

Reference: (Danaher and Cagney 2004b; Hanley and Hurley 2013)

The site was identified in advance of roadworks on the N22 Ballincollig bypass and was fully excavated in July and August 2002. Two groups of Neolithic features were identified at Ballinaspig More site 5. The first group consists of four post-holes (C.57, C.55, C.49 & C.45) and their respective fills. The former three were located in a closely-knit group aligned in a northeast–southwest direction while C.45 was situated *c.*0.5m southeast of the most southern of these, C.49. The four posts were of roughly similar dimensions with depths ranging from *c.*0.13–0.3m. The deposits contained within the posts C.57, C.55 and C.49 were very similar consisting of silty clays with moderate charcoal and pebble inclusions. Whereas the fill of post C.45 also consisted of a silty clay it contained less charcoal.

The second group of Neolithic features was comprised of pits and post-holes but also contained a small number of stake-holes and a hearth, with pottery sherds, grinding and chipped stone artefacts as well as nut-shell fragments and cereal grains being located within a number of these. Although these features did not form any discernible structure they appeared to be of a domestic nature. Ten post-holes (C.1132, C.1153, C.1136, C.1134, C.1188, C.1189, C.1186, C.1193, C.1195, C.1191) were identified. Most were of similar shape and size with a diameter and depth of no greater than 0.42m and 0.2m respectively. Three pits (C.1149, C.1150, C.1160) were also located within this area. Pit C.1150 was the smallest of these pits with a diameter of slightly in excess of 0.5m and depth of 0.2m. It contained a loose dark silty sand coloured deposit (C.1145) with occasional small stone and quartz inclusions as well as sherds of Early Neolithic Carinated Ware and a piece of flint. Its northern extent was truncated by pit C.1149, which had a slightly larger diameter but similar depth. The fill (C.1143) contained within this pit was similar to deposit C.1145 but with added inclusions of nutshells and a single cereal grain. Pit C.1160, situated a few metres to the northwest of C.1149, was a shallower pit which contained a lighter coloured silty sand fill (C.1159) with inclusions of charcoal and pebbles. Also located within this zone of Neolithic activity was a small hearth C.1140 with a diameter of 0.7m and depth of 0.06m. It had been oxidised to a bright orange colour as a result of direct contact with high temperatures and contained two fills, C.1139 and C.1137. The former of these was the primary fill consisting of a thin spread of charcoal-rich material, which was sealed by C.1137 a second deposit of hearth-like material with occasional burnt hazelnut shells present throughout its extent.

A fourth pit C.1090 (not shown) contained a loose silty clay deposit (C.1089) with frequent inclusions. These mainly consisted of sub-angular stones, quartz, charcoal (oak & alder), pottery, flint debitage, beaker pottery and nutshell fragments, possibly hazelnut.

Ceramics

This small assemblage contains the remains of at least two and possibly a third vessel. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. All were recovered from group 2 of the site, pits C.1134, C.1149, C.1150.

Archaeobotanical remains

Archaeobotanical remains were recovered from two contexts in group 2, pit C.1149 and hearth C.1140. There was a single wheat grain, perhaps emmer and charred hazelnut shells were identified from fill C.1143 of pit C.1149. Additional charred hazelnut shells were identified in upper fill C.1137 of hearth C.1140.

Radiocarbon dating

Four Neolithic radiocarbon dates were obtained from the excavation at Ballinaspig More (site 5) (see Table B.4). Oak charcoal from post-hole C.55 of group 1 features returned a date of 3965-3665 cal BC. Two radiocarbon determinations were obtained from group 2 features, oak charcoal from post-hole C.1134 was dated to 3946-3656 cal BC, while pit C.1149 returned a date range of 3796-3382 cal BC. An element of confusion exists regarding this date as the original excavation reports lists the material dated from C.1149 as charcoal, however, the later publication *Generations: the archaeology of five national road schemes in county Cork* (Hanley and Hurley 2013) list the dated material as emmer wheat. A fourth Neolithic date (*Beta-178207*, 3636-3367 cal BC) was returned from alder charcoal from pit C.1090, however, this charcoal was recovered from fill C.1089 which contained diagnostically Late Neolithic/Early Bronze Age material (beaker pottery) and may not relate to Neolithic activity at the site.

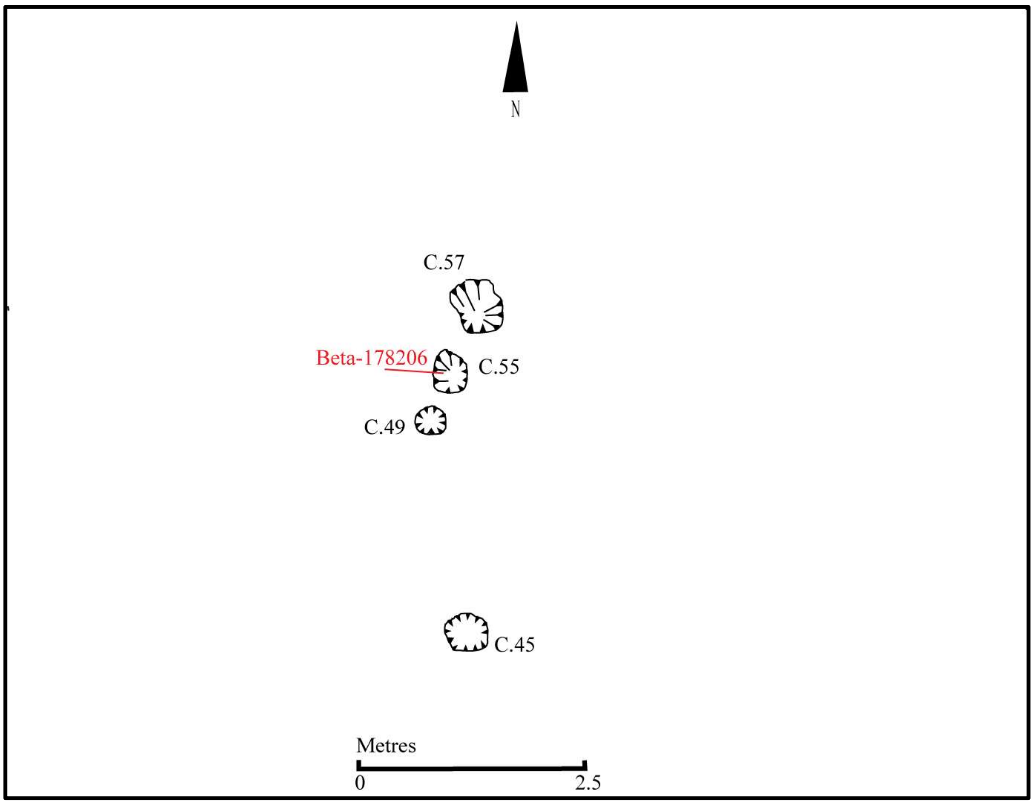

Figure B.9 Early Neolithic features (group 1) at Ballinaspig More site 5

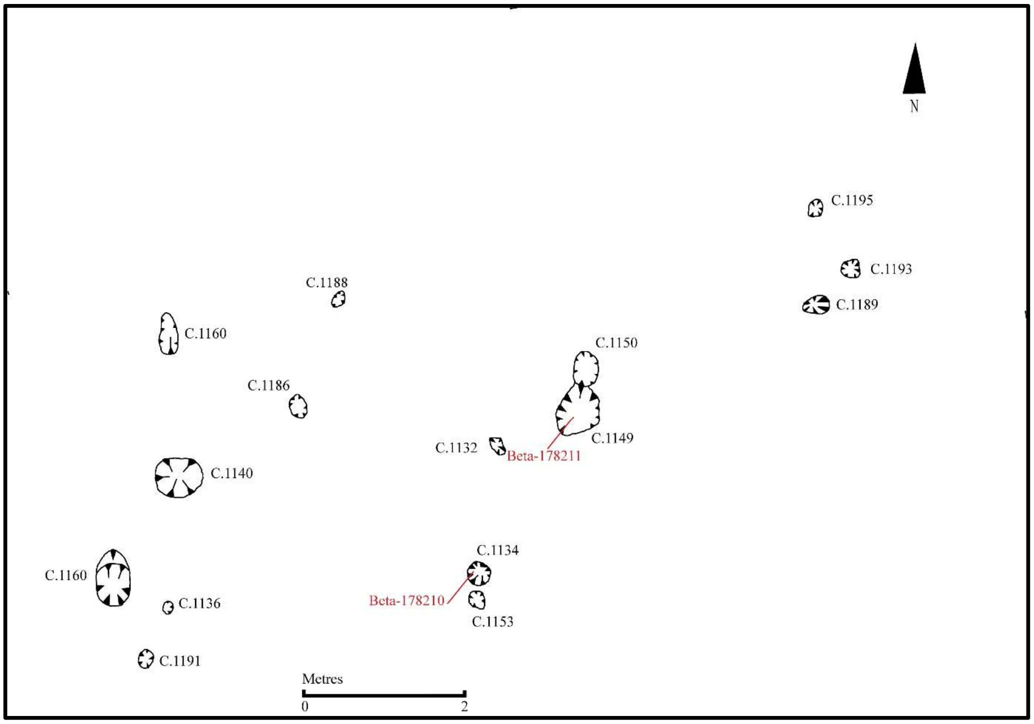

Figure B.10 Early Neolithic features (group 2) at Ballinaspig More site 5

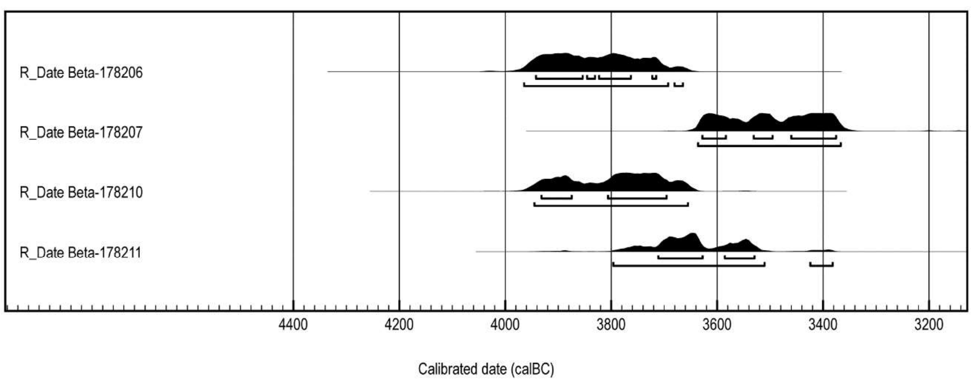

Figure B.11 Calibrated radiocarbon date from Ballinaspig More site 5

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2б) 95.4% Probability	Calibrated Age (1б) 68.2% Probability
Beta – 178206	C.55	Oak Charcoal	5030 ± 70	3965-3693BC (93.5%) 3681-3665BC (1.9%)	3942-3854BC (36.4%) 3846-3831BC (5.2%) 3824-3764BC (23.9%) 3723-3716BC (2.6%)
Beta-178207	C.1090	Alder Charcoal	4710 ± 70	3636-3367BC (95.4%)	3628-3584BC (18.1%) 3532-3496BC (14.8%) 3460-3376BC (35.3%)
Beta - 178210	C.1134	Oak Charcoal	4990 ± 70	3946-3656BC (95.4%)	3932-3875BC (19.8%) 3806-3696BC (48.4%)
Beta - 178211	C.1149	Wheat Grain	4860 ± 70	3796-3511BC (92.7%) 3424-3382BC (2.7%)	3712-3628BC (47.2%) 3586-3530BC (21.0%)

Table B.4 Calibrated radiocarbon date from Ballinaspig More site 5

(7) Townland: Ballindud

Barony: Gaultiere

County: Waterford

Site Type: Portal Tomb

SMR: WA017-016----

Excavation Licence Number: N/A

ITM: 660155, 608799

National Grid: 260217, 108745

OD: 0-50m

Reference: (Ryland 1824, 299-300; Atkins 1896, 71; Borlase 1897, vol 1, 62-63; Ó Nualláin 1983, 103; Moore 1999, 1)

Situated in rough pasture, on a gentle west facing slope *c.*4km south of the River Suir and *c.*8km north of Tramore Bay. A subcircular roof-stone, *c.*4.3m by *c.*3.8m with a maximum thickness of *c.*1m is supported on one stone and facing south west. It is depicted in Ryland (1824, 299-300) as supported on a second portal-stone with a tall back-stone. These are no longer present. The site has not been excavated.

(8) Townland: Ballinglanna North (site 3)

Barony: Condons and Clangibbon

County: Cork

Site Type: Neolithic rectangular houses and associated features

SMR: N/A

Excavation Licence Number: E2416

ITM: 581348, 604864

National Grid: 181393, 104809

OD: 100m

Reference: (Johnston and Tierney 2010)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between September 2006 and September 2007.

Structure 1

A large rectangular structure (Structure 1) was identified at this site. This building measured 9.6m long by 6.7m (external dimensions) and 7.5m by 5.2m (internal dimensions). The long-axis of the building was aligned roughly east to west.

The eastern wall

The eastern foundation trench (C.109) was aligned north/south and was linear with a flat base and vertically sloping sides. Early Neolithic pottery and charred hazelnut shells were recovered from one of the fills (C.106). A deposit of discarded hearth contents (C.93) was found in the northern part of the foundation trench. It contained carbonised hazelnut shell fragments and flecks of burnt bone. There were two post-holes (C.99 and C.126) at each end of this wall. The post-hole C.99 was located at the south-east corner, where it connected with the southern foundation trench (C.108). At the north-east corner of the house a post-hole (C.126) connected this foundation trench with the northern wall (C.110). A post-pipe (C.114) was identified in the fill of this post-hole. Pottery and burnt hazelnut shell fragments were found in the fill of the post-pie (C.115).

The northern wall

The northern foundation trench (C.110) was orientated east/west. Two post-holes (C.138 and C.164) were found within the northern wall (C.110). Post-hole C.164 was situated at the western corner and post-hole C.38 was found at the centre of the foundation trench. The central post-hole (C.138 contained a post-pipe (C.127), the dimensions of which suggested that the original post was c. 0.6m in diameter.

The southern wall

The southern foundation trench (C.108) was aligned east/west and was linear with gently sloping sides. This foundation trench contained a post-hole (C.98) at the western end and was adjoined to C.109 by a post-hole (C.99) at its eastern end. Both post-holes contained packing stones that originally held posts in place and the fills of the corner post-hole (C.99) contained pottery sherds. The deposit (C.97) was found throughout the northern, eastern and southern foundation trenches (C.110, C.109 and C.108 respectively). It was made up of light brownish yellow clayey silt with inclusions of pebbles, small stones and charcoal; twenty fragments of pottery and a piece of flint were recovered from this fill.

The western wall

The western foundation trench (C.82) contained post-holes (C.118, C.120, C.121, C.124, C.125 and C.122) and a pit (C.119). The north-western corner of the house was marked by a post-hole (C.118). In contrast to the other foundation trenches in Structure 1, which were straight, the western foundation trench was irregular, forming an almost curved arc at the western end of the building. It also contained irregularly spaced post-holes, unlike the other foundation trenches. This irregularity may be a result of collapse and/or repair.

The entrance

The entrance to Structure 1 was in the southern wall, along the long axis of the house. It was placed roughly in the centre of the wall and it was 1.2m wide.

Pits

There were three pits (C.1190, C.131 and C.149) associated with Structure 1. Pit C.1190 (not shown) cut the western foundation trench (C.82) and the remaining two pits (C.131 and C.149) were located within the structure. Charcoal was found within the pit fills but there was no evidence for *in situ* burning. Pottery fragments were also recovered from some pit fills. A total of twenty-one pits were located to the east of Structure 1. Most pit fills contained moderate quantities of charcoal apart from pit (C.193) which was charcoal-rich. It is possible that this pit was used as a hearth. Burnt clay (which could be the remnants of Neolithic pottery) in pit (C.207) is also indicative of human activity. A cluster of four pits (C.193, C.179, C.207 and C.234), located just east of Structure 1, are probably contemporary with the structure and therefore probably date to the Early Neolithic. The remaining pits were scattered over a wide area and it is possible that some were natural features where re-deposited archaeological deposits accumulated gradually during occupation of the site.

Domestic activity in the north-east of the site

Seven possible pits (C.291, C.316, C.340, C.423, C.465, C.758 and C.799) were found *c.*20m to the north-east of Structure 1. Pottery from this area was identified as sherds of Early Neolithic Carinated Ware, suggesting that these pits were roughly contemporary with the occupation of both Structure 1 and Structure 2.

Structure 2

A rectangular building (Structure 2) was located in the southern part of the site. It measured approximately 12.5m in length by 6m in width and it was aligned east/west. The northern portion of the building was truncated by later activity, probably dating to the Bronze Age.

The southern wall

The southern wall was characterised by a foundation trench (C.810), which also incorporated the linear cuts (C.495, C.536 and C.578, not shown). It was aligned east to west and it measured 6.3m in length. Sherds of pottery, a piece of worked stone and a flint flake was recovered from the fill.

The eastern wall

The eastern wall was characterised by the linear feature C.608. It was aligned north/south and it measured 0.32m in length, but it did not extend for the full width of Structure 2. wall.

The western wall

The western wall was represented by linear feature (C.644), post-holes (C.610 and C.721) and stake-holes (C.723 and C.726).

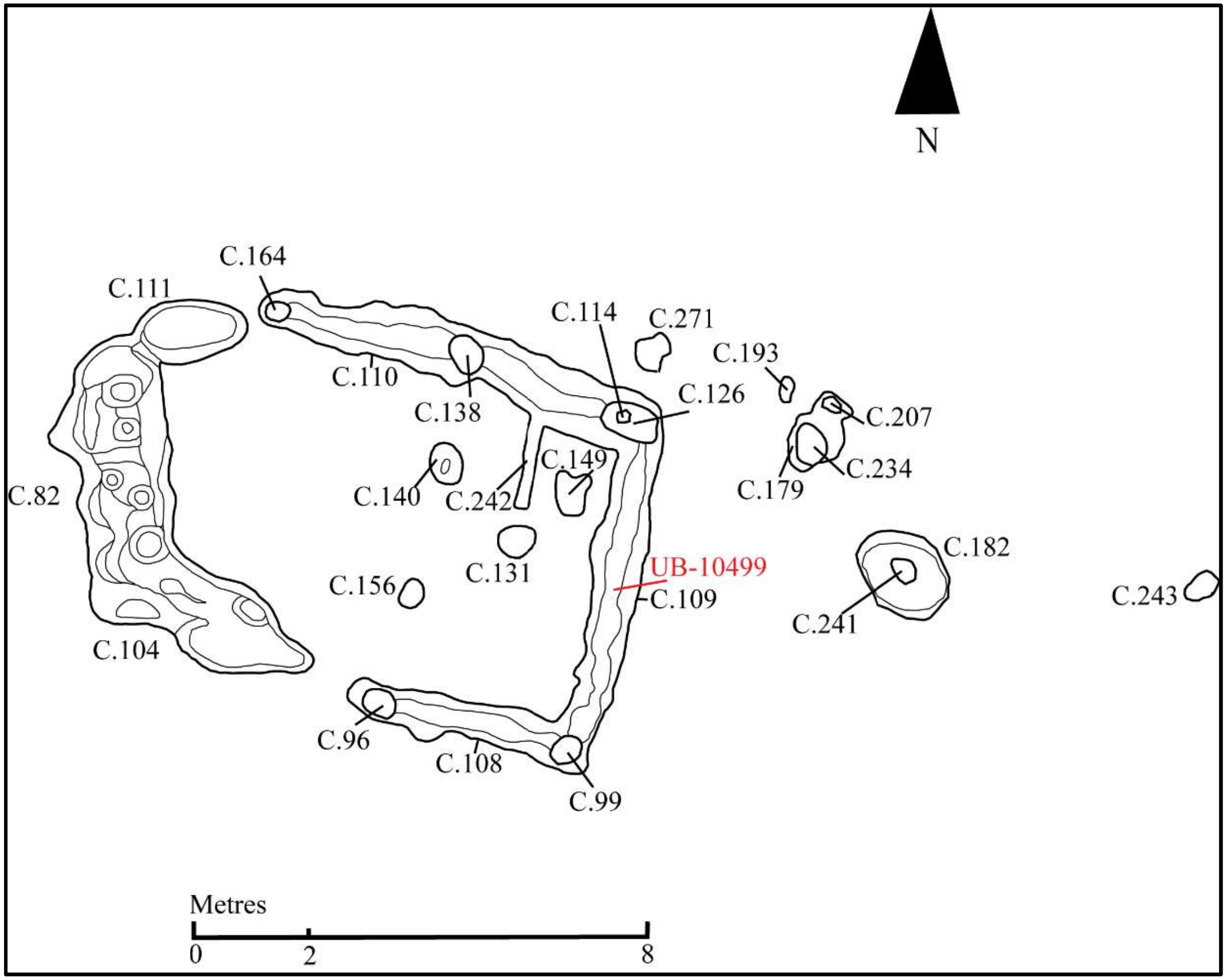

Figure B.12 Ballinglanna North (site 3) structure 1

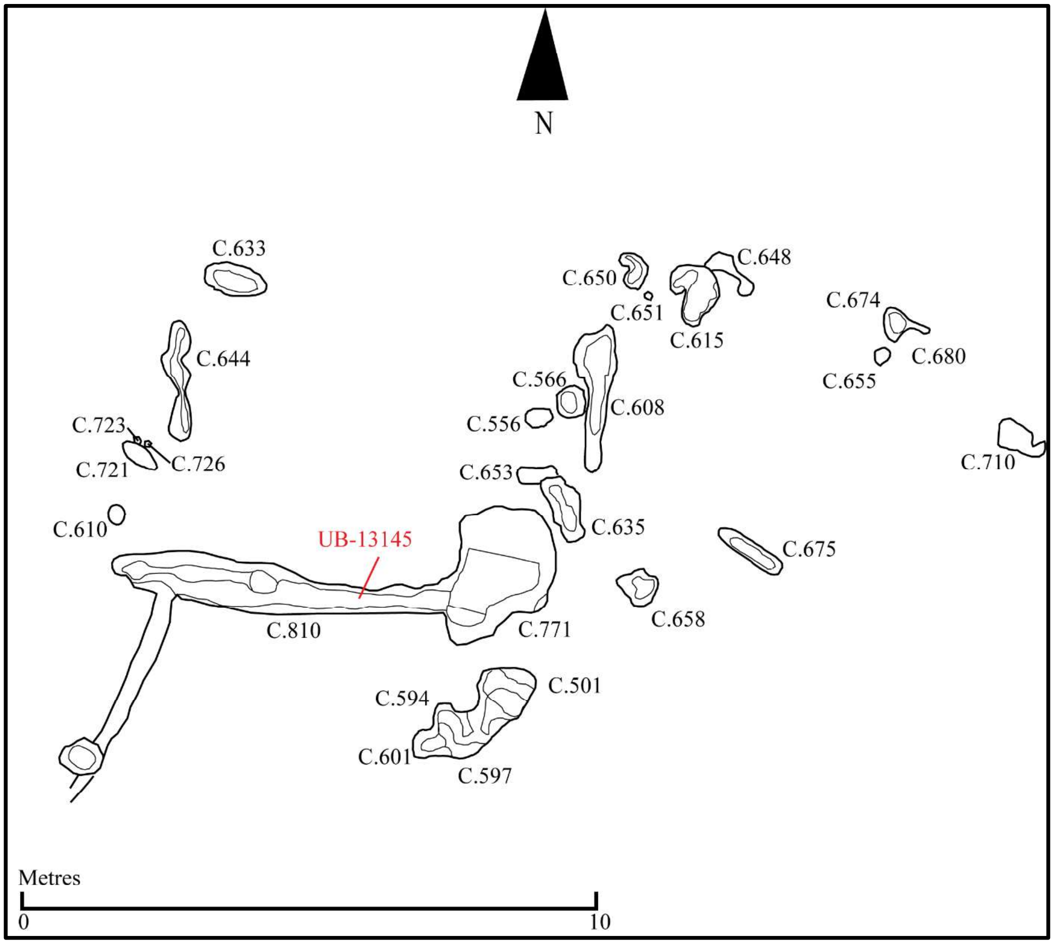

Figure B.13 Ballinglanna North (site 3) structure 2

The northern wall

The northern part of the structure was truncated. It is unclear where the northern wall of the building was originally located. Later activity at the site, probably dating to the Bronze Age, truncated some of the activity at this part of the site.

The entrance

The large pit (C.771) was probably originally a post-hole. Pit C.771 and post-hole C.658 cut the footing trench for the southern wall (C.810) and they may have originally held large posts that marked the entrance to the house.

The possible annex

A possible annex was represented by features beyond the eastern wall of Structure 2. Pits (C.615, C.648, C.658, C.674 and C.675), a post-hole (C.655) and a slot trench (C.680). These suggest a curvilinear arc of features at the eastern end of the building, making this a D-shaped annex at the end of a rectangular house.

External features

To the south of the southern wall there were four inter-cutting pits (C.501, C.594, C.597 and C.601) that contained some pottery fragments.

Ceramics

The site produced 320 sherds of pottery representing at least 36 separate vessels. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. Vessel 1 was recovered during topsoil stripping, vessels 2-12 from occupation horizon C.12. Vessels 13-27 were recovered from structure 1 (C.38, C.98, C.99, C.104, C.109, C.111, C.114, C.131, C.149, C.240, C.241, C.243 and C.271), vessels 28-30 from pit C.423 and furrow C.426 to the north-east of structure 1. Vessels 31-33 were recovered from structure 2 (C.628, C.648, C.650, C.655, C.658, C.679 and C.710), while vessels 34-36 were found within the *fulacht fia* which truncated the northern part of structure 2.

Lithics

Twenty lithic finds from the archaeological excavations of a prehistoric site in the townland of Ballinglanna North 3. A bipolar split flint pebble core, eight flakes are all made of flint, two scrapers (a small crude scraper and a fine example of a Neolithic convex end scraper) and two miscellaneous artefacts (a flake most likely used as some form of scraper and a very large knife and/or side scraper produced on a mudstone flake). The assemblage comprises predominately artefacts which date to the second half of the Neolithic period. Within the later Neolithic component, the presence of a single platform and a large retouched mudstone flake suggests a use of this location the Late Mesolithic or, more likely, in the Early Neolithic.

Archaeobotanical remains

The archaeobotanical assemblage from Ballinglanna North (site 3) contained charred hazelnut shell fragments and emmer wheat grain and chaff. Emmer grains were recovered from features in Structure 1 (C.104, C.111, C.114, C.240, C.271 and C.299) and from features in Structure 2 (C.810). Emmer chaff was also recovered from 3 contexts from both structures (C.111, fills C.686 & C.704 of C.810) perhaps suggesting that domestic activities, such as crop processing, were probably carried out.

Radiocarbon dating

Three Neolithic radiocarbon dates were obtained from the excavation at Ballinglanna North (site 3) (see Table B.5). Hazelnut shell fragment from fill C.106 of foundation trench C.109 produced an Early Neolithic radiocarbon date of 3766–3656 cal BC. Hazel charcoal from the fill C.290 of pit C.291 returned a radiocarbon date of 3939– 3706 cal BC. Hazel charcoal from fill C.532, of C.536 (not shown), part of foundation trench C.810 returned a radiocarbon date of 3938–3708 cal BC.

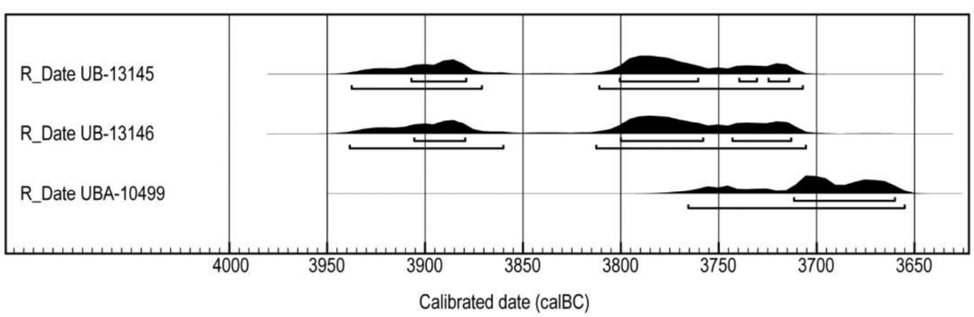

Figure B.14 Calibrated radiocarbon dates from Ballinglanna North (site 3)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
UB–13145	C.801 (C.536)	Hazel Charcoal	5010 ± 25	3938-3872 cal BC (31.4%) 3812-3708 cal BC (64.0%)	3908-3880 cal BC (19.7%) 3801-3761 cal BC (37.1%) 3740-3731 cal BC (4.8%) 3725-3714 cal BC (6.5%)
UB–13146	C.291	Hazel Charcoal	5007 ± 28	3939-3860 cal BC (29.6%) 3813-3706 cal BC (65.8%)	3906-3880 cal BC (15.7%) 3800-3758 cal BC (34.5%) 3744-3714 cal BC (17.9%)
UBA–10499	C.109	Hazelnut Shells	4936 ± 21	3766-3656 cal BC	3712-3660 cal BC

Table B.5 Calibrated radiocarbon dates from Ballinglanna North (site 3)

(9) Townland: Ballyhenebery

Barony: Iverk

County: Kilkenny

Site Type: Portal Tomb

SMR: KK038-009----

Excavation Licence Number: N/A

ITM: 644455, 624297

National Grid: 244514, 124246

OD: 0-100m

Reference: (Borlase 1897, 408; Ó Nualláin 1983, 98)

In a slight hollow in rolling pasture *c.*3.2km north of the River Suir. A roof-stone *c.*5m by *c.*3.5m with a maximum thickness of *c.*0.7m rests on a ruined chamber. A portal-stone *c.*1.7m high and door-stone *c.*1.7m high are also noted. The site has not been excavated.

(10) Townland: Ballykeoghan (site AR11)

Barony: Ida

County: Kilkenny

Site Type: Pit

SMR: N/A

Excavation Licence Number: E2501

ITM: 658345, 619067

National Grid: 258408, 119016

OD: 35m

Reference: (Wren 2010)

The site at Ballykeoghan (site AR11) was exposed as part of the programme of advance archaeological investigation on the proposed Alternative Route on the N25 Waterford to Knocktopher Road Improvement Scheme. The excavation was conducted from 23rd August to the 4th October 2006. A sub-rectangular pit (C.115) with irregular sloping sides and a rounded base was uncovered in the southwest corner of AR11. Five sherds of prehistoric pottery and charred plant remains, including wheat grains and some indeterminate cereal grains, were recovered from fill C.114. Three of the pottery sherds were from an Early Neolithic vessel probably a carinated bowl and the other two were form the neck of a Bell Beaker. A sample of the charred barley returned a calibrated radiocarbon date of 2275-2038 cal BC (3744±26 BP, *UBA-13978*). As the pottery was worn and found in a context which dated to the Bronze Age it may be residual.

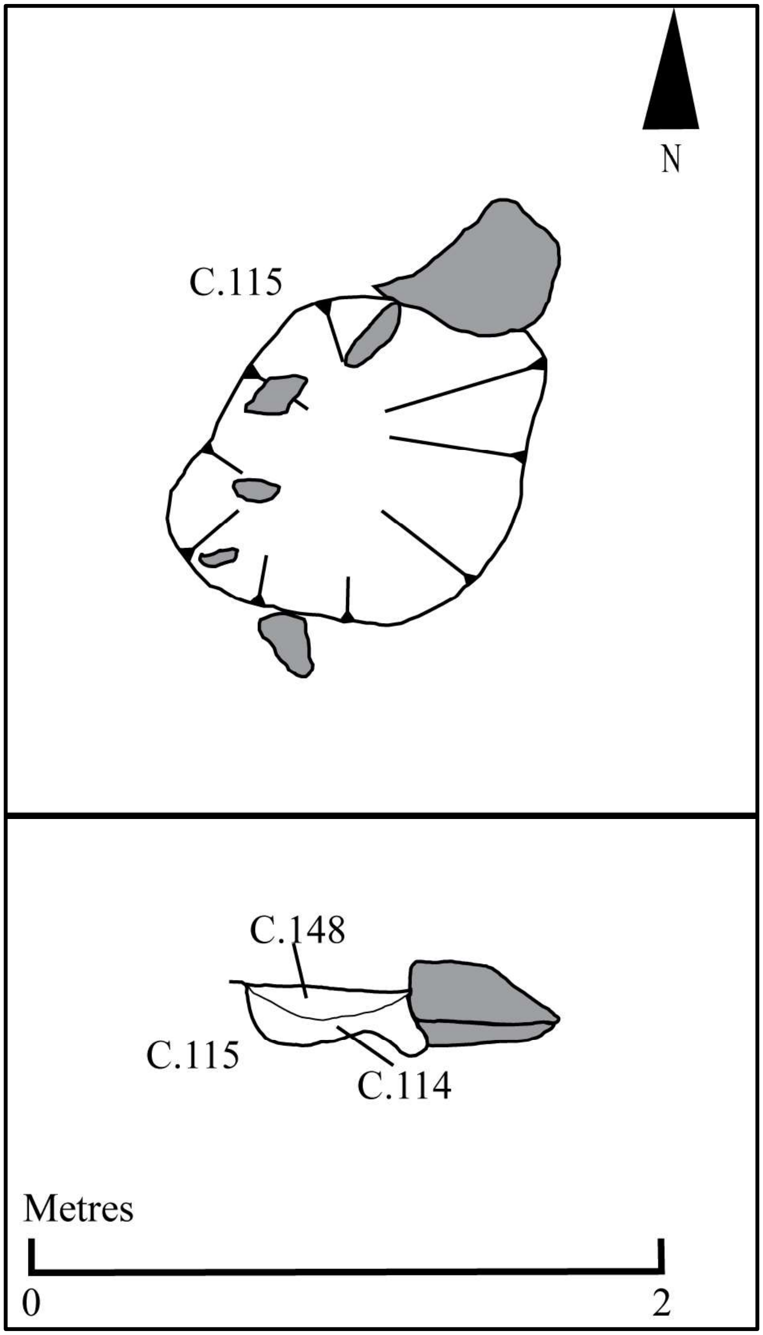

Figure B.15 Neolithic feature Ballykeoghan (site AR11)

(11) Townland: Ballylowra

Barony: Knocktopher

County: Kilkenny

Site Type: Portal Tomb

SMR: KK032-009001-

Excavation Licence Number: N/A

ITM: 655567, 637921

National Grid: 255628, 137873

OD: 200-300m

Reference: (Graves 1850, 130; Ó Nualláin 1983, 97)

Site no longer present but sketched by Graves (1850) showing portal-stone, door-stone and displaced roof-stone Situated at the foot of a ridge c0.5km east of a tributary of the River Suir

(12) Townland: Ballynacarriga (site 3)
Barony: Condons and Clangibbon
County: Cork
Site Type: Hearth and associated stake holes
SMR: N/A
Excavation Licence Number: E2412
ITM: 581424, 602656
National Grid: 181469, 102600
OD: m
Reference: (Lehane and Leigh 2010)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between September 2006 and September 2007. To the north-west of the main Bronze Age enclosure of the site, a hearth (C.507) and a group of six post-holes (C.500, C.528, C.544, C.511, C.5503 and C.516) were excavated. The hearth (C.507) contained three fills (C.506, C.517 and C.525) that varied from red clay at the top to silt at the base with inclusions of pebbles, stones and charcoal. There is no indication whether the hearth was for domestic or industrial use. Charcoal from the hearth was identified as diffuse porous wood type; preservation was so poor that it could not be identified to genus level. This charcoal returned an Early Neolithic radiocarbon date. As there were no finds from this area of the site, it is impossible either to corroborate the date, or to suggest that the dated material was re-deposited or old wood. There was an arc of four post-holes (C.500, C.503, C.528 and C.544) around the hearth, to its west. These may have acted as a windbreak around the hearth. A further two post-holes (C.511 and C.516) were located approximately 1m further west.

Radiocarbon dating.

A single Early Neolithic radiocarbon date was obtained from the excavation at Ballynacarriga (site 3) (see Table B.6). Unidentified charcoal from fill C.506 of hearth C.507 returned a date range of 3796-3664 cal BC.

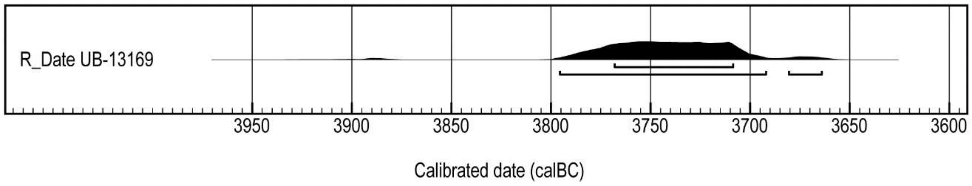

Figure B.16 Calibrated radiocarbon date from Ballynacarriga (site 3)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-13169	C.507	Charcoal	4969±25	3796-3692 cal BC (92.3%) 3681-3664 cal BC (3.1%)	3768-3709 cal BC

Table B.6 Calibrated radiocarbon date from Ballynacarriga (site 3)

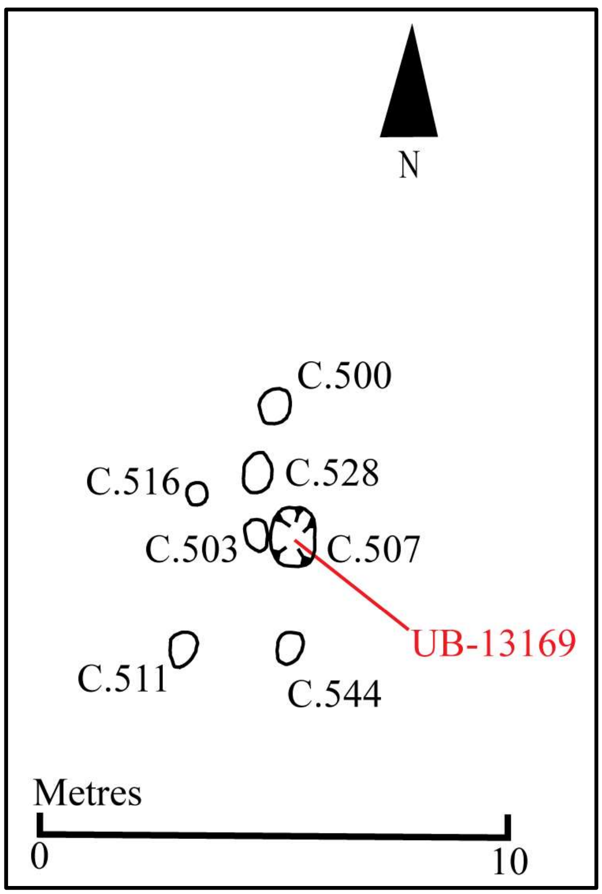

Figure B.17 Hearth and associated stake-hole from Ballynacarriga (site 3)

(13) Townland: Ballynageeragh

Barony: Middlethird

County: Waterford

Site Type: Portal Tomb

SMR: WA025-007----

Excavation Licence Number: N/A

ITM: 649455, 603121

National Grid: 249515, 103065

OD: 200-300m

Reference: (Du Noyer 1866, 480; Atkins 1896, 68-69; Mongey 1941, 3-5; Herity 1964, 135; Ó Nualláin 1983, 103; Harbison 1992, 325; Moore 1999, 1)

The site is situated in pasture on a broad plateau with a slight E-facing slope, *c.*4km north of the coast. An oval roof-stone *c.*4m by *c.*2.65m and a maximum thickness of *c.*0.7m rests on the septal-slab and the back-stone with a cushion-stone between the roof-stone and the back-stone. The tomb, which faces south-west, lacks portal-stones but the side-stones are present. The site was investigated and conserved in 1939-40 when cremated bone, flint and charcoal were found in the chamber (Herity 1964, 135).

(14) Townland: Ballynamona (site 1)
Barony: Condons and Clangibbon
County: Cork
Site Type: Pit
SMR: N/A
Excavation Licence Number: E2428
ITM: 582567, 611513
National Grid: 182612, 111459
OD: m
Reference: (Tierney and Johnston 2011)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between February and March 2007.A cluster of pits were excavated in Area 2 of the site. One pit (C.86) contained nine sherds of prehistoric pottery, all identified as being from one Grooved Ware vessel. The pottery indicates activity in the Late Neolithic. An Early Neolithic date range was returned for pit C.86, however, the pit appeared heavily truncated in modern times (possibly due to agricultural activities) and this may suggest that the dated material was re-deposited or old wood.

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation of Area 2, Ballynamona (site 1) (see Table B.7). Hazel/alder charcoal found within pit C.86 returned a radiocarbon date of 3761–3643 cal BC.

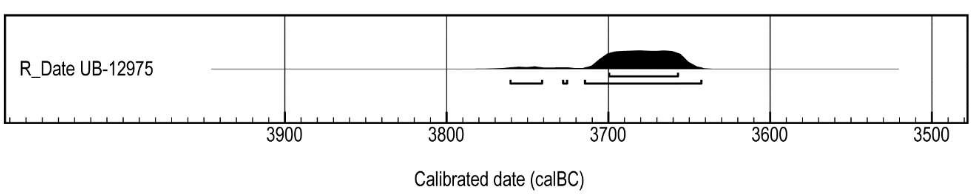

Figure B.18 Calibrated radiocarbon date from Ballynamona (site 1)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
UB-12975	C.86	Hazel/Alder Charcoal	4912 ± 25	3761-3742 cal BC (3.6%) 3728-3726 cal BC (0.3%) 3715-3643 cal BC (91.5%)	3700-3658 cal BC

Table B.7 Calibrated radiocarbon date from Ballynamona (site 1)

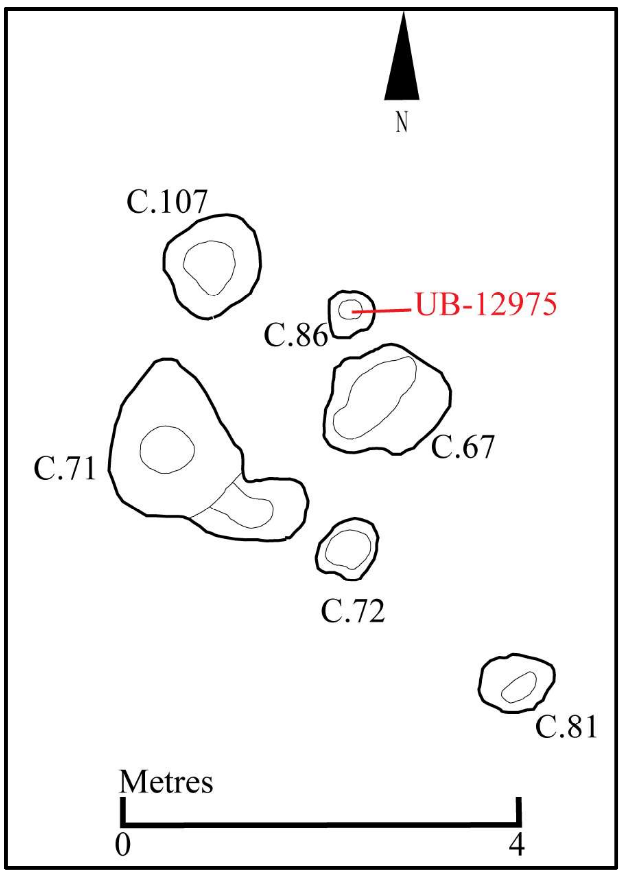

Figure B.19 Pit C.86, Area 2, Ballynamona (site 1)

(15) Townland: Ballynamona (site 2)
Barony: Condons and Clangibbon
County: Cork
Site Type: Pit
SMR: N/A
Excavation Licence Number: E242
ITM: 582746, 611784
National Grid: 182791, 111730
OD: 90-100m
Reference: (Hegerty 2010)
The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between February and March 2007. Two isolated pits (C.171 and C.173) were found at the extreme north of Area 1. The artefacts recovered from these pits indicated a Neolithic date of occupation; fragments of prehistoric was found within the fill of the pit (C.173). Lithic finds from this part of the site also indicate a Neolithic date of activity, with types from both the Early and the Late Neolithic found.

Ceramics

The site produced a small assemblage of eleven sherds of pottery representing up to nine separate vessels. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. Most of the Early Neolithic carinated bowl pottery was recovered from topsoil stripping in Area 1, sherds were also recovered from a natural depression (C.28) and a pit (C.173).

Lithics

The assemblage comprises predominately Neolithic diagnostic elements such as the four convex end scrapers, invasively retouched forms, and the large single platform blades and flakes. The use of a bipolar method to reduce some of the flint pebble suggests a possible use of the site during the second half of the Neolithic. A platform core rejuvenation flake represents use of the site during the first half of the Neolithic period.

(16) Townland: Ballynella
Barony: Barrymore
County: Cork
Site Type: Pit
SMR: N/A
Excavation Licence Number: 09E0059
ITM: 587908, 591667
National Grid: 187954, 91609
OD:
Reference: (Molloy 2010; Cleary 2015b)

A single oval pit (F.3) was identified in advance of Bord Gáis pipeline works between Curraleigh and Middleton. The pit measured 0.9m by 0.7m with a maximum depth of 0.19m. The fill (F.4) consisted of sandy gravel with some charcoal (mainly hazel with lesser amounts of ash) inclusion. Also recovered in the fill of F.3 were thirteen sherds of pottery and forty pieces of flint. No radiocarbon dates were obtained for this site.

Ceramics

Thirteen sherds of pottery were identified during excavation, a rim sherd and twelve other fragmentary pieces of varying size, representing at least one vessel. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

Forty pieces of flint were recovered from fill (F.4) of pit (F.3), identified as two small end scrapers, thirty-two pieces of debitage and six unutilised split flint chunks. The presence of debitage suggests flint knapping was undertaken on site.

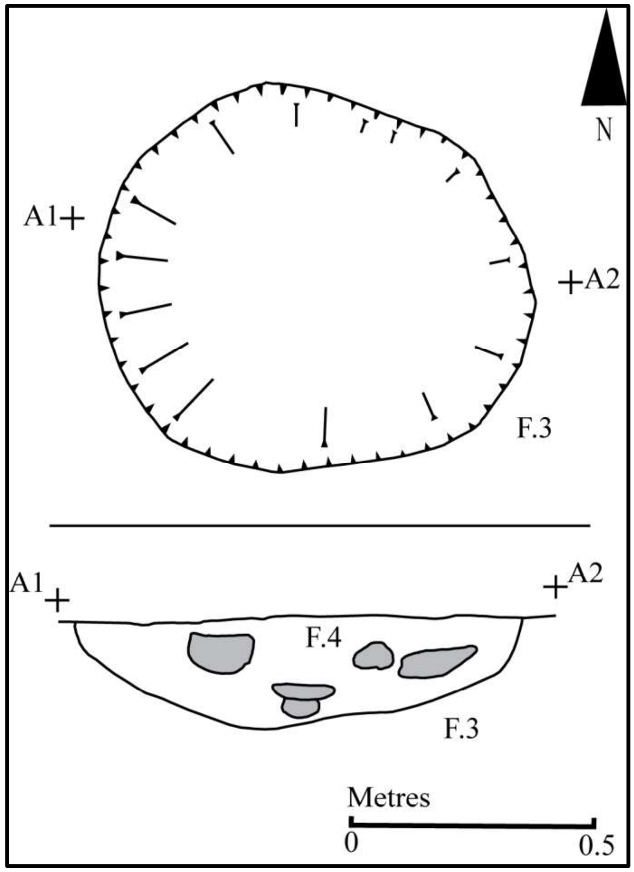

Figure B.20 Pit from Ballynella in plan and section after Molloy (2010)

(17) Townland: Ballyquin

Barony: Upperthird

County: Waterford

Site Type: Portal Tomb

SMR: WA003-049----

Excavation Licence Number: N/A

ITM: 641124, 618044

National Grid: 241182, 117992

OD: 200-300m

Reference: (Blackett 1851; Borlase 1897; O'Flanagan 1929; Ó Nualláin 1983; Power *et al.* 1992)

Located in pasture on the floor of a north-west, south-east valley, *c.*50m from a stream. The chamber faces north-east with the portal stones aligned on this axis. A triangular roof-stone measuring *c.*4.15m by *c.*2.5m with a maximum thickness of *c.*1.1m resets on two portal-stones, *c.*1.5m high. No other structural stones are present. The site has not been excavated.

A second possible portal tomb is listed on the 1st edition OS 6-inch map as being *c.*50m east of the extant tomb in Ballyquin townland. No trace of this now remains.

(18) Townland: Barnagore (site 3)

Barony: East Muskerry

County: Cork

Site Type: Neolithic Rectangular House

SMR: CO073-120----

Excavation Licence Number: 02E0384

ITM: 556390, 569780

National Grid: 156430, 69717

OD: m

Reference: (Danaher 2003; 2009; 2013a)

The site was identified in advance of roadworks on the N22 Ballincollig bypass and was fully excavated in March and April 2002. The site consisted of a single structure measuring 6.4m by 5.4m with an internal floor area of 34.5m². The site was defined by a series of foundation trenches, which likely held split timber oak planks on two sides with panels of wickerwork or wattle and daub on the others.

The slot trenches

The southern (C.79) and western (C.73) walls consisted of pronounced slot trenches cut into the subsoil. The eastern (C.38) wall was incomplete consisting of a discontinuous slot trench with a post-pit (C.127) present in the southeast corner and another (C.32) situated just under a meter and a half north of this a light screening may have constituted the remainder of this wall. Five possible post-pits, (C.53, C.57, C.122, C.125 & C.127), were located within western and southern slot trenches. The northern (C.74) wall was not constructed in the same way and would appear to have consisted of panels of wickerwork or wattle and daub set into a shallow slot trench. The possible post pit (C.123) in the east corner differed from the three present in the remaining corners of the structure as there was less evidence for stone packing while two stake-holes C.33, C.26 were cut into the base of this feature. Four other stake-holes (C.98, C.99, C.47 & C.70) were unearthed within this feature while the charred wood remains of two possible timber uprights were revealed (C.5 & C.8). This wall was possibly composed of panels of wickerwork or wattle and daub as is suggested by the stake-holes. The east wall consisted of a discontinuous slot trench, C.38, running north-south, and contained post pits, C.127 and C.32, within its southern and northern extents respectively. The basal remains of an *in-situ* burnt stake, C.27, was located between these two features but was not cut into the base of the slot trench C.38. It is possible that these two posts may have supported a lighter wall cladding, as is suggested by C.27, this wall possibly resembled the northern wall more than its western and southern counterparts. No evidence for any features was present north of C.38 with a gap of almost 2.5m separating this feature from the north wall. No structural evidence for the location of an entrance/doorway was noted during the excavation, but the lack of any foundation trenches in the northeastern side of the house suggested that this was the most likely point for an entrance.

Internal features

A number of cut features were exposed within the house but not all were associated with it, post-pit C.22 and possible post-hole C.28 were located within the centre of the house across its shorter axis and possibly carried a central beam from which rafters would have extended towards the corners. Both features appeared to be too insubstantial to have accommodated structural posts. They may have also formed part of an internal partition, movable screens could have been placed upon these posts, thus providing a means of dividing the room in a number of ways.

External features

Two stake-holes were excavated south of the southern slot trench, the most western of these, C.118, was located just outside the southwest corner of the structure while the second stake-hole C.63 was present *c.*1.2m east of it. These were the only stake-holes present outside of the structural walls. No artefactual remains were recovered during excavation.

Archaeobotanical remains

The archaeobotanical assemblage from Barnagore (site 3) consisted of fragments charred hazelnut shells. These were recovered from fills, C.6 & C.30 of post-hole C.28 and fills C.75 & C.77 of the western slot trench C.73.

Radiocarbon dating

Two Early Neolithic radiocarbon dates were obtained from the excavation at Barnagore (site 3) (see Table B.8). Oak charcoal from stake-hole C.27 returned a radiocarbon date of 3922-3388 cal BC. Oak charcoal from fill C.88 of foundation trench C.38 returned a date of 3943-3638 cal BC.

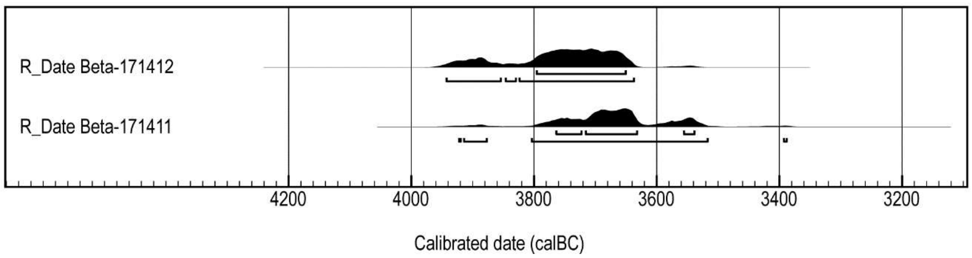

Figure B.21 Calibrated radiocarbon date from Barnagore (site 3)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Beta - 171411	C.27	Oak Charcoal	4880 ± 70	3922-3920 cal BC (0.1%) 3914-3878 cal BC (2.2%) 3804-3518 cal BC (92.9%) 3393-3388 cal BC (0.2%)	3764-3723cal BC (12.7%) 3716-3632 cal BC (49.9%) 3556-3539 cal BC (5.6%)
Beta - 171412	C.38	Oak Charcoal	4950 ± 70	3943-3854 cal BC (16.9%) 3846-3830 cal BC (1.7%) 3824-3638 cal BC (76.8%)	3796-3651 cal BC (68.2%)

Table B.8 Calibrated radiocarbon date from Barnagore (site 3)

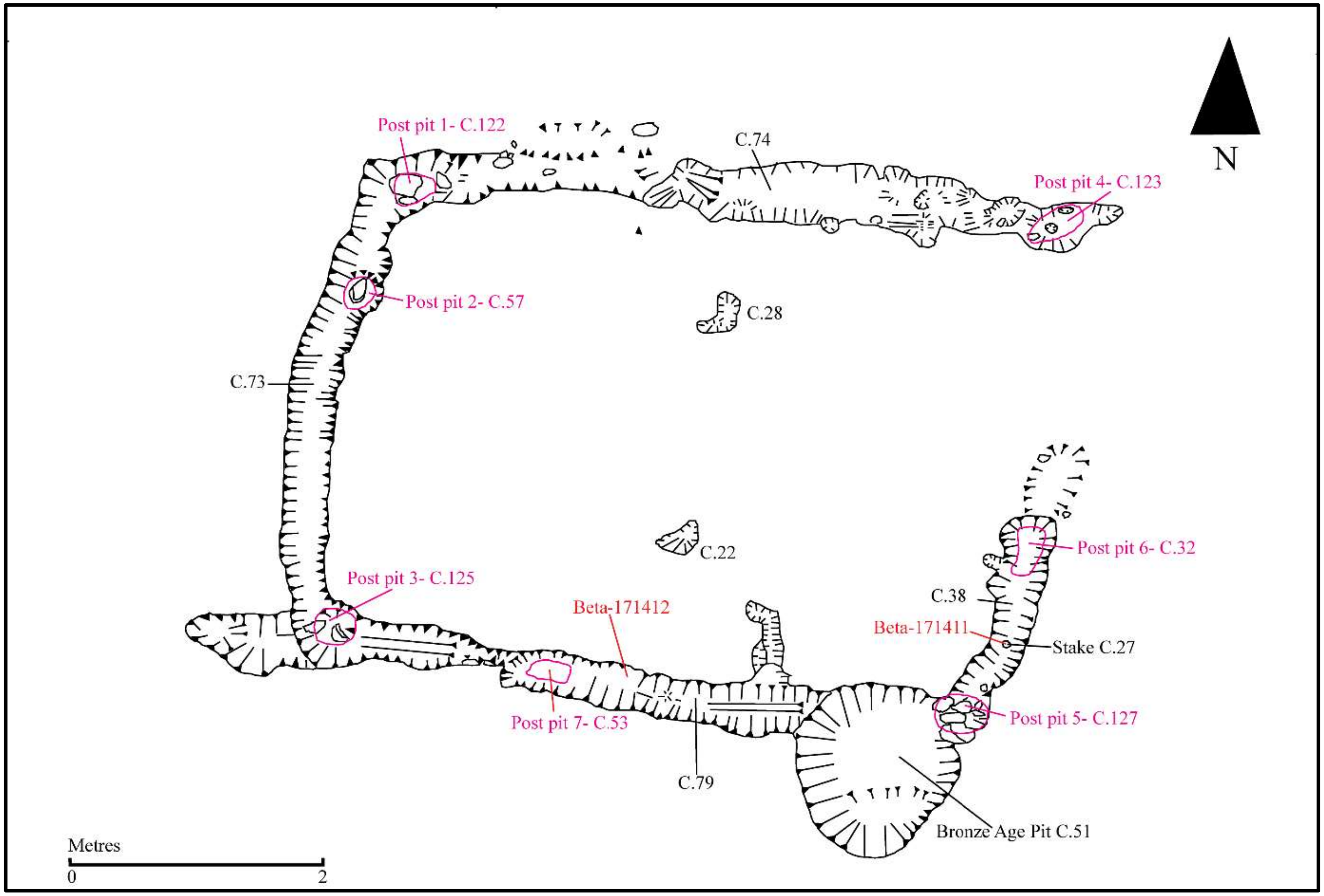

Figure B.22 Barnagore (site 3)

(19) Townland: Bawnfune (site 2)

Barony: Middlethird

County: Waterford

Site Type: Slot trench and post-holes

SMR: N/A

Excavation Licence Number: 05E0763, E3446

ITM: 654777, 609727

National Grid: 254838, 109673

OD: 30m

Reference: (Russell 2006; 2008; 2010a; Lennon 2009; 2010; Lennon *et al.* 2011)

The site at Bawnfune (site 2) was exposed as part of the programme of advance archaeological investigation on the proposed Alternative Route on the N25 Waterford Bypass undertaken in 2005 by Ian Russell under licence number 05E0763. The site was fully resolved July 2007 (E3446).

Slot-trenches

The slot-trench F.002 was orientated east–west and measured 1.16m in length, 0.52m in width and 0.3m in depth. A total of four pieces of struck flint were recovered from the fill (F.003) of slot trench F.002. The second slot-trench F.008 was exposed 1.0m to the east of F.002. It was orientated northwest–southeast shape and measured 1.21m in length, 0.45m in width and 0.21m in depth.

Post-holes

The post-hole F.010 was located 0.75m to the west of the slot trench F.002. It was circular in shape and measured 0.26m in diameter to a depth of 0.15m. The post-hole F.017 was exposed 5.25m to the south of the post-hole F.010 and the slot trenches F.002 & F.008. It was circular in shape and measured 0.29m in diameter to a depth of 0.15m. The post-hole F.019 was exposed 0.8m to the southeast of F.017 and 5.55m to the south of the post-hole F.010.

Lithics

The assemblage comprises two blades, one flake and two retouched artefacts. The two blades were produced on single platform beach flint nodules. Both blades are broken into two and three pieces respectively. The flake was produced on a single platform beach flint nodule and displays extensive use-wear and polish on its right edge. The two retouched artefacts are a miscellaneous retouched artefact and an end-of blade scraper. The assemblage is typologically and technologically diagnostic. End-of-blade scrapers generally date to the Neolithic (Woodman *et al.* 2006).

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation at Bawnfune (site 2) (see Table B.9). Hazel charcoal from post-hole F.019 returned a date range of 3764-3538 cal BC.

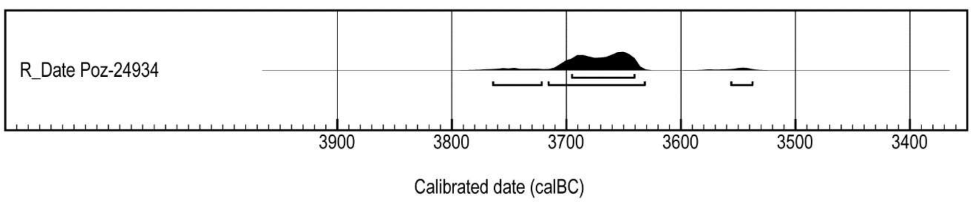

Figure B.23 Calibrated radiocarbon date from Bawnfune (site 2)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Poz-24934	F.019	Hazel Charcoal	4880 ± 40	3764-3722 cal BC (5.9%) 3716-3632 cal BC (86.4%) 3556-3538 cal BC (3.1%)	3696-3641 cal BC

Table B.9 Calibrated radiocarbon date from Bawnfune (site 2)

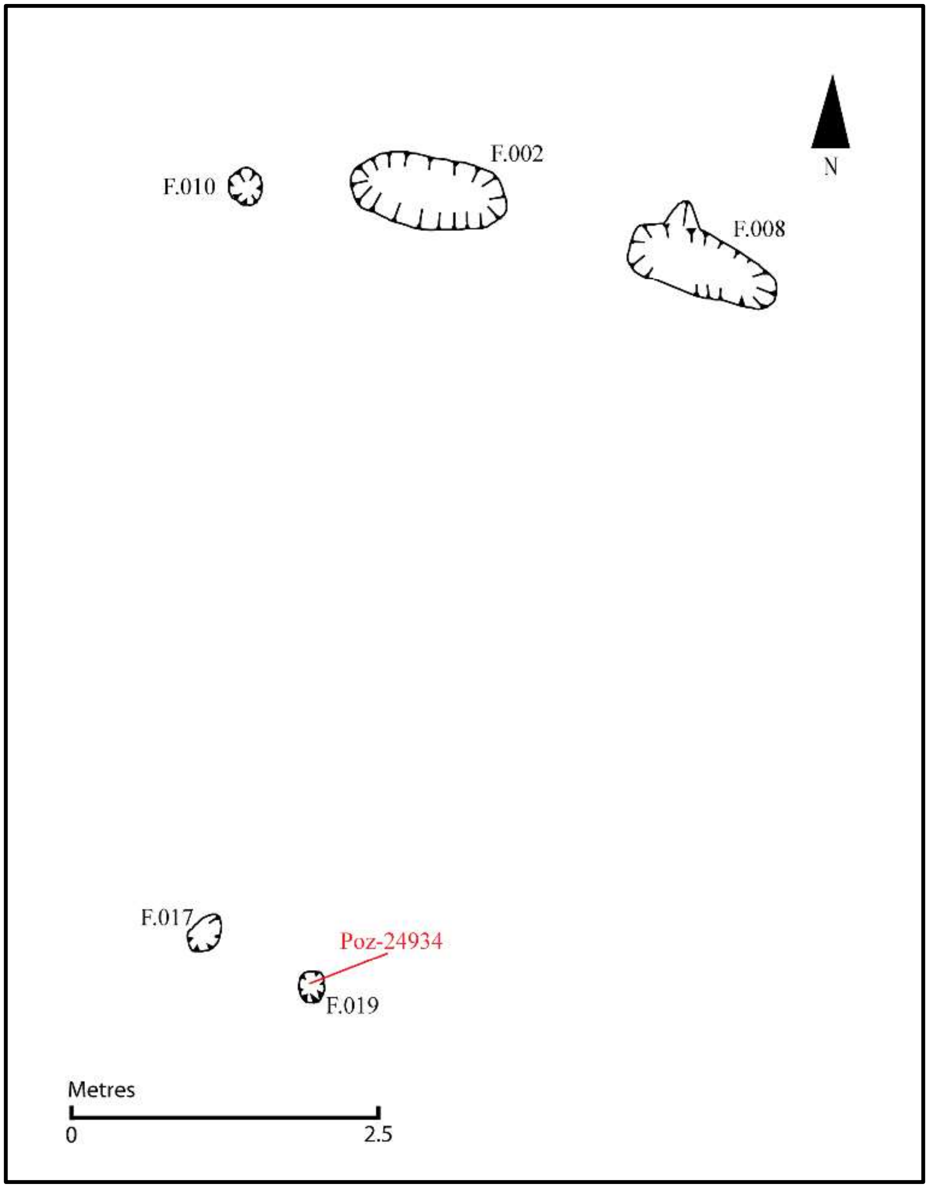

Figure B.24 Neolithic features Bawnfune (site 2)

(20) Townland: Butlerstown North (site 2)

Barony: Middlethird

County: Waterford

Site Type: Pits

SMR: WA017-137----

Excavation Licence Number: E3440

ITM: 655347, 610318

National Grid: 255409, 110265

OD: 17m

Reference: (Russell 2006; 2008; O'Hara 2009; O'Hara and Ginn 2011)

The site at Butlerstown North (site 2) was exposed as part of the programme of advance archaeological investigation on the proposed Alternative Route on the N25 Waterford Bypass undertaken in 2005 by Ian Russell under licence number 05E0763. The site was fully resolved September 2007 (E3440).

Pits

The largest of the pits (F.004) was located in the centre of the site. It contained two fills, lower fill F.003 and upper fill F.002. Contained within the lower fill were five sherds of prehistoric pottery and two pieces of flint debitage. The upper fill (F.002) contained occasional charred hazelnut shells. A second pit F.006 was located 2.2m to the southeast of F.004 and was filled by F.014 (lower fill) and F.005 (upper fill), a flint flake was recovered from fill F.005. No radiocarbon dates were returned for Butlerstown North (site 2)

Ceramics

The site produced eight sherds of pottery representing at least four and possibly more vessels. All were recovered from fill F.003 from pit F.004. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

The assemblage comprises three flakes and one retouched artefact. The flakes were produced on single platform cores produced on small beach flint nodules. The retouched artefact is a very small leaf shaped arrowhead. The assemblage is typologically and technologically diagnostic. Leaf-shaped arrowheads generally date to the first half of the Neolithic (Woodman *et al.* 2006). In addition, the single platform technology was the dominant technology used during this period.

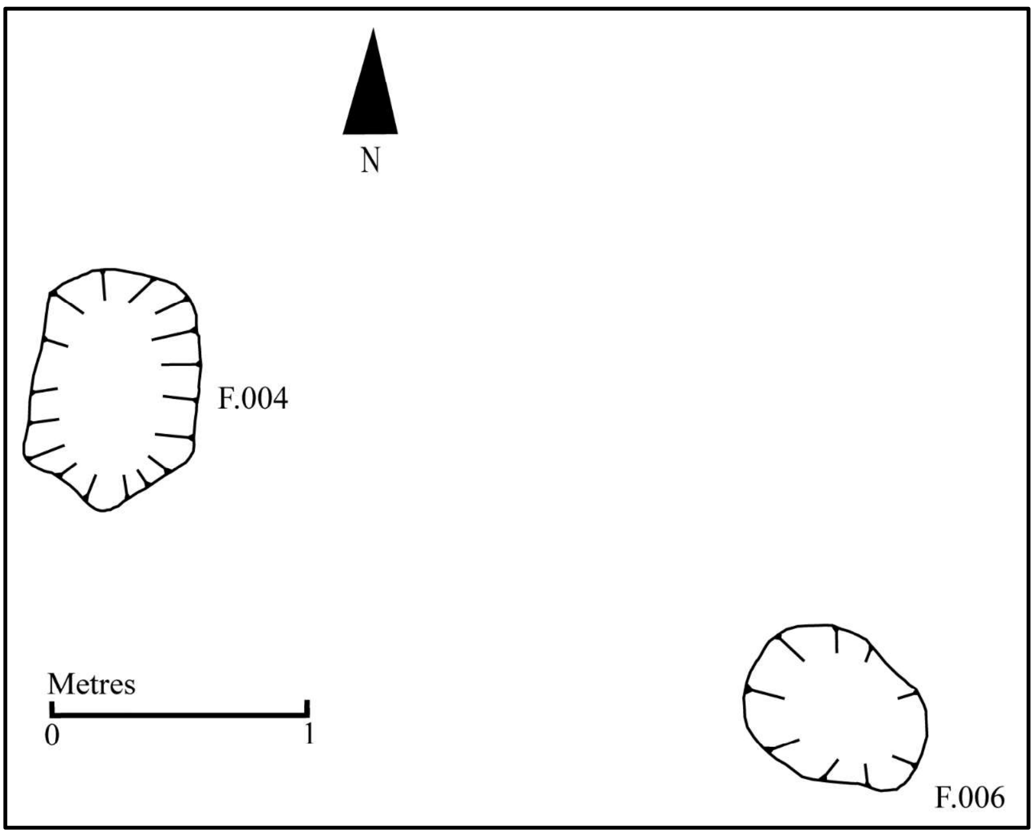

Figure B.25 Neolithic features Butlerstown North (site 2)

(21) Townland: Caherabbey Lower (site 189.1)

Barony: Iffa and Offa West

County: Tipperary

Site Type: Pits

SMR: N/A

Excavation Licence Number: E2266

ITM: 604859, 626656

National Grid: 204909, 126606

OD: 60-70m

Reference: (McQuade 2007a)

The site at Caherabbey Lower (site 189.1) was identified in advance of roadworks on the N8 Cashel to Mitchelstown Road Improvement Scheme and was fully excavated in May 2006. There were two pairs of pits on the site, one on the northeastern end and the other on the southern end. The northern pits F.4 and F.6 were similarly sized and oval in plan. Seventeen sherds of pottery and two flint tools were found in fill F.3 of pit F.4. A single charred mustard/ cabbage seed was also recovered from fill F.3. The second pit F.6 was located 0.48m northeast of F4. It had two fills F.15 and F.5. The lower fill (F.15) contained two sherds of pottery. The upper fill (F.5) was confined to the centre of the pit, seven sherds of pottery and two flint tools were recovered from this fill. The second pair of pits F.12 and F.14 was located 11.88m to the south of the northern pits. They were also oval in plan and were of a similar size. Pit F.12 had two fills F.11 and F.16. Plant remains identified within fill F.11 included hazel nut shell and seeds of fat hen. The second pit F.14 was 0.53m east of F12. Fragments of hazelnut shells, raspberry/blackberry and docks were identified within the fill (F.13). Twelve sherds of pottery and an incomplete flint flake were also found in fill F.13. No radiocarbon dates were obtained for the Neolithic features at Caherabbey Lower.

Ceramics

The site produced 30 sherds of pottery, representing at least three vessels, from the fills of pits F.14, F.4 and F.6. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

Nine lithic artefacts were recovered during the excavation of Site 189.1 in Caherabbey Lower. Four of the artefacts in the assemblage came from topsoil and are therefore of limited interpretative potential. Two lithics came from F.4, two further lithics came from F6 and the remaining artefact came from F14 located at the southern end of the site. The lithics were identified as retouched bipolar core, end and side scraper, retouched blade and flint flakes. No chronologically diagnostic pieces were present in the assemblage. However, the general form of the artefacts is indicative of a broad Neolithic to Early Bronze Age date for the activity represented.

Archaeobotanical remains

Archaeobotanical remains were recovered from three contexts at Caherabbey Lower. A single charred mustard/ cabbage seed was recovered from fill F.3 of pit F.4. The mustard/cabbage genus contains a number of edible species including mustard, cabbage, and turnip found along roadsides and streams/river edges (Stace 1997). Fill F.11 of pit F.12 contained primarily hazelnut shell fragments (97%). Four fat-hen seeds and a single indeterminate cereal grain were also identified. Fat-hen is a common weed of arable lands and is generally harvested with cereal crops. The identified plant remains suggest that the pit F.12 contained domestic refuse. Fill F.13 of pit F.14 contained a few fragments of charred hazelnut shells, two charred raspberry/blackberry seeds and a single charred dock seed. Docks are weeds of arable lands and grow within cereal crops and are generally harvested along with the crop and brought onsite.

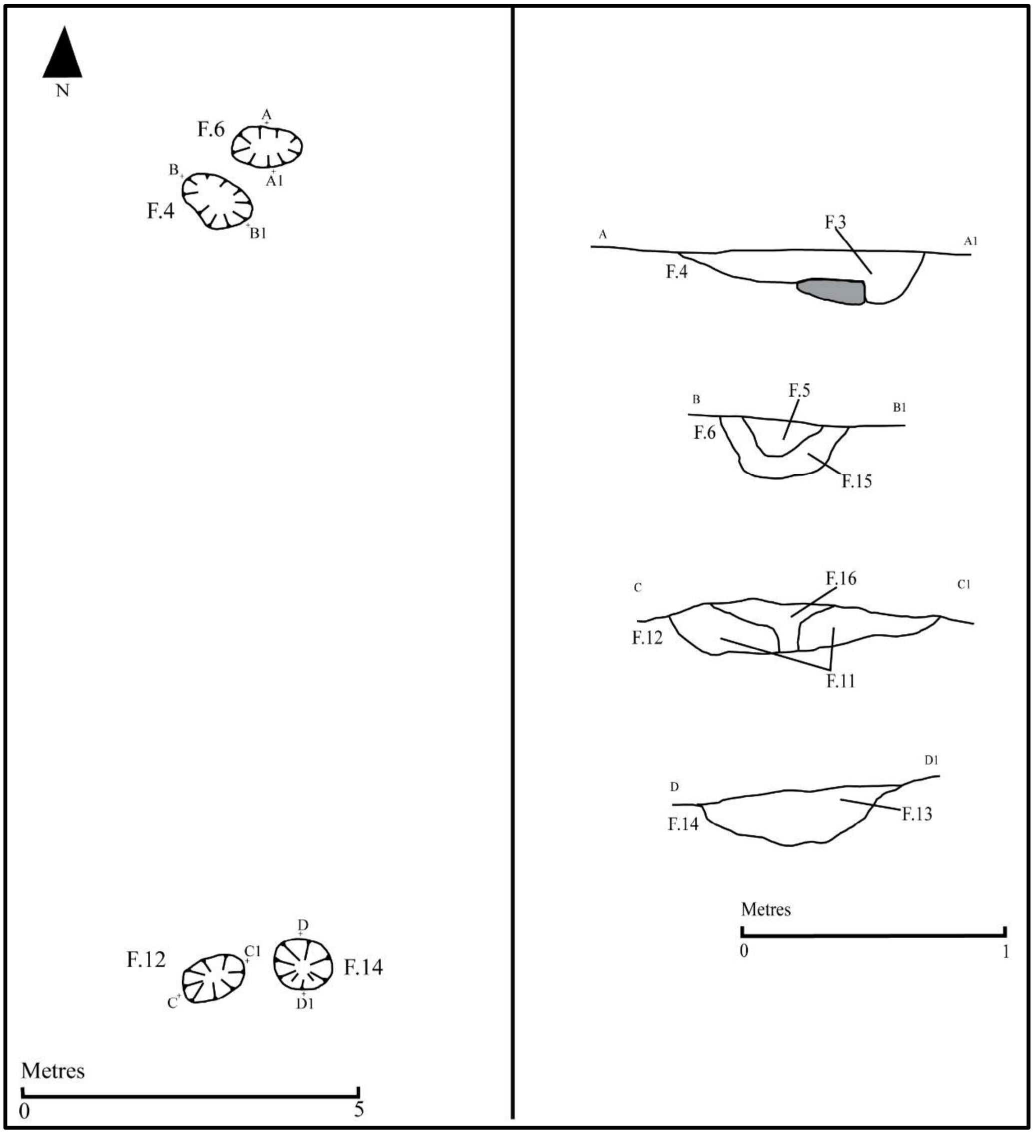

Figure B.26 Neolithic features Caherabbey Lower (site 189.1) in plan and section

(22) Townland: Caherabbey Upper (site 185.1-4)
Barony: Iffa and Offa West
County: Tipperary
Site Type: Possible hut structure and associated features
SMR: N/A
Excavation Licence Number: E2298
ITM: 604112, 626110
National Grid: 204163, 126059
OD: 70m
Reference: (Molloy 2007a; 2009; Grogan and Roche 2007; Halwas 2007)
The site at Caherabbey Lower (site 189.1) was identified in advance of roadworks on the N8 Cashel to Mitchelstown Road Improvement Scheme and was fully excavated in May 2006. Early Neolithic activity was confined to area 1 of the site.

Area 1

Area 1 was located at the southwestern extent of the site. This area had been scarped along its northern extent and as a result it is likely some archaeological features were truncated. The remains of a possible structure (Structure 1) were identified towards the southern extent of this area. Clusters of stake-holes were identified to the south and east of the possible structure and are likely to be associated with the structure. These did not form any coherent plan or structure. Four pit features (F.37, F.31, F.23 & F.21) were identified approximately 3m to the north of Structure 1. Two large pit features (F.76 & F.139) were identified approximately 6m to the northeast of Structure 1.

Structure 1

A cluster of post-holes was identified in this area, within an area measuring 7m (N-S) by 4m. Post-holes/stake-holes F.111. F.114, F.43, F.124, F.141, F.107, F.105, F.104, F.79, F.72, F.65, F.122 & F.53 formed a double semi-circular or arc, measuring approximately 5m (N-S) in length, which could represent some kind of fence-line, windbreak or perhaps the truncated remains of a structure. The secondary fill (F.52) of post-hole F.53 produced an Early Neolithic radiocarbon date. High quantities of charred and encrusted seed fragments including indeterminate cereals, emmer wheat and hazel nut fragments were identified within this deposit.

Internal Features

Two post-holes (F.103 & F.74), a stake-hole (F.116) and a pit feature (F.81) were identified within the area encompassed by the semi-circular line of post-holes. Fill F.82 of pit F.81 produced indeterminate cereal grains.

Associated stake-holes

Eight stake-holes (F.87, F.85, F.89, F.93, F.91, F.83, F.126 & F.101) were identified to the south and east of the semi-circular line of post-holes. No specific plan or pattern was evident in the layout of these features, but it is likely that they are all associated.

Pit Features

Four pit features (F.37, F.23, F21 & F31) were identified approximately 3m to the north of the possible structure. Hazel nut fragments, possible emmer wheat and cereal chaff fragments were identified in fill F.46 of pit F.37. Two further large pits (F.76 & F.139) were identified 4m to the east of Pits F.21, F.23, F.31 & F.37 and approximately 6m to the east of Structure 1. Two stake-holes, F128.1 & F128.2, were identified at the base of the pit F.76.

Ceramics

Area 1 of the site produced sherds of pottery, two were conjoined necksherds representing 1 vessel retrieved during test excavation and are not stratified. The remaining sherd was from a beaker vessel and was recovered from the upper fill F.51 of post-hole F53. This is likely to be an intrusive find as the secondary fill (F52) of this post-hole produced an Early Neolithic radiocarbon date. The conjoined necksherds sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Archaeobotanical remains

The fill F.52 of the post-hole F53 contained high quantities of highly charred and encrusted seed fragments, indeterminate cereals, possible emmer wheat and very few hazelnut shell fragments and nipplewort. A few fragments of wheat rachis were also recovered. Rachis is the basal portion of the structure that attaches the grain to the spikelet which is removed during crop processing. The recovery of large quantities of rachis and chaff indicates processing was carried out nearby. The presence of wheat chaff would indicate that cereal processing took place near-by. The identification of emmer wheat within the assemblage is of particular interest as emmer is the most common wheat identified at sites in Ireland dating to the Neolithic (Halwas 2007). The primary fill F46 of pit F37 contained abundant moderately encrusted hazelnut shell fragments; a few encrusted indeterminate cereal grains and possible emmer wheat grains and two cereal chaff fragments were also recovered. The charred and encrusted nature of the remains suggests re-deposited accumulation of domestic refuse. A considerable quantity of indeterminate cereal grains was also recovered from fill F.82 of pit F.81.

Radiocarbon dating

One Early Neolithic radiocarbon dates were obtained from the initial excavation at Caherabbey Upper (site 185.1-4) (see Table B.10). Oak charcoal from post-hole C.53 returned a radiocarbon date of 3986-3798 cal BC. Further radiocarbon dates were obtained as part of the Heritage Council funded, *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Six Neolithic radiocarbon dates were returned from wheat grains.

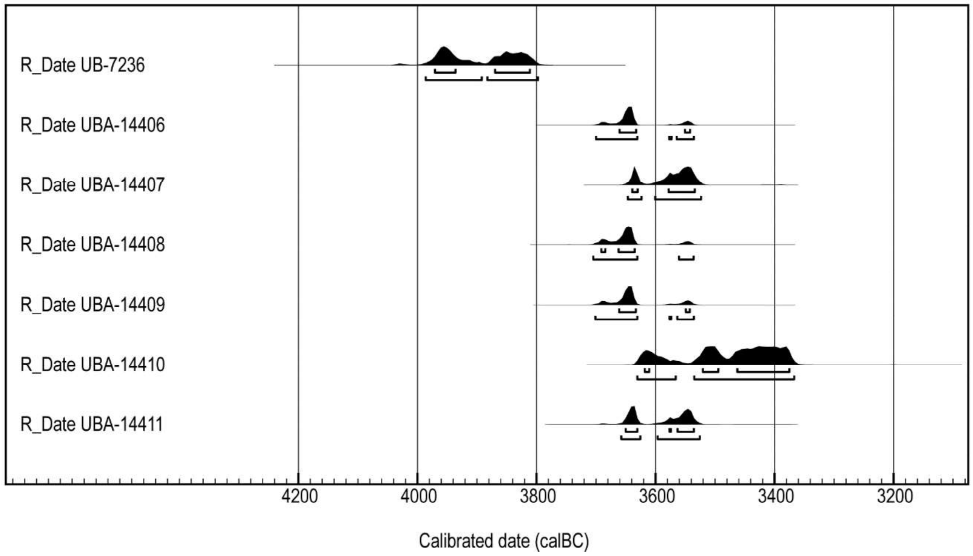

Figure B.27 Calibrated radiocarbon dates from Caherabbey Upper (site 185.1-4)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-7236	F.53	Oak Charcoal	5119 ± 38	3986-3892 cal BC (46.8%) 3883-3798 cal BC (48.6%)	3971-3936 cal BC (29.4%) 3870-3812 cal BC (38.8%)
UBA-14406	F.37	Wheat Grain	4849 ± 28	3700-3631 cal BC (81.2%) 3578-3574 cal BC (0.6%) 3565-3536 cal BC (13.6%)	3661-3633 cal BC (62.0%) 3551-3542 cal BC (6.2%)
UBA-14407	F.37	Wheat Grain	4801 ± 28	3647-3624 cal BC (20.0%) 3601-3524 cal BC (75.4%)	3640-3630 cal BC (12.2%) 3578-3534 cal BC (56.0%)
UBA-14408	F.81	Wheat Grain	4856 ± 30	3705-3631 cal BC (86.6%) 3561-3536 cal BC (8.8%)	3692-3685 cal BC (6.2%) 3662-3636 cal BC (62.0%)
UBA-14409	F.81	Wheat Grain	4850 ± 29	3702-3631 cal BC (81.6%) 3577-3574 cal BC (0.5%) 3564-3536 cal BC (13.3%)	3662-3634 cal BC (63.2%) 3550-3543 cal BC (5.0%)
UBA-14410	F.53	Wheat Grain	4693 ± 43	3631-3566 cal BC (17.8%) 3536-3368 cal BC (77.6%)	3618-3611 cal BC (3.5%) 3521-3495 cal BC (15.0%) 3463-3376 cal BC (49.7%)
UBA-14411	F.53	Wheat Grain	4822 ± 30	3658-3626 cal BC (37.2%) 3597-3526 cal BC (58.2%)	3650-3631 cal BC (30.5%) 3577-3574 cal BC (1.9%) 3564-3536 cal BC (35.8%)

Table B.10 Calibrated radiocarbon dates from Caherabbey Upper (site 185.1-4)

Two statistically consistent radiocarbon dates, *UBA-14406* and *UBA-14407* (T'=1.5; T'(5%)=3.8; v=1) from pit F.37 (Ward and Wilson 1978), two statistically consistent radiocarbon dates *UBA-14408* and *UBA-14409* (T'=0.0; T'(5%)=3.8; v=1) (Ward and Wilson 1978) from pit F.81 were included in the Bayesian model for activity at Caherabbey Upper. *UBA-14410* and *UBA-14411* from post-hole F.53 were shown to be statistically inconsistent (T'=6; T'(5%)=3.8; v=1) (Ward and Wilson 1978), however *UBA-14411* was shown to be statistically consistent with the other dates from Caherabbey Upper (T'=2.7; T'(5%)=9.5; v=4) (Ward and Wilson 1978) and was therefore also included in the model. *UB-7236* was obtained from oak charcoal and has been treated as *terminus post quem* for activity at the site. These five dates were plotted using OxCal 4.2.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the activity at Caherabbey Upper. Bayesian modelling returned a date range of *3690-3540 cal BC (95% probability), 3660-3640 cal BC (68% probability)* for the start of occupation at Caherabbey Upper and a date range of *3660-3530 cal BC (95% probability), 3650-3630 cal BC (68% probability)* for the end of occupation ($A_{overall}$=162).

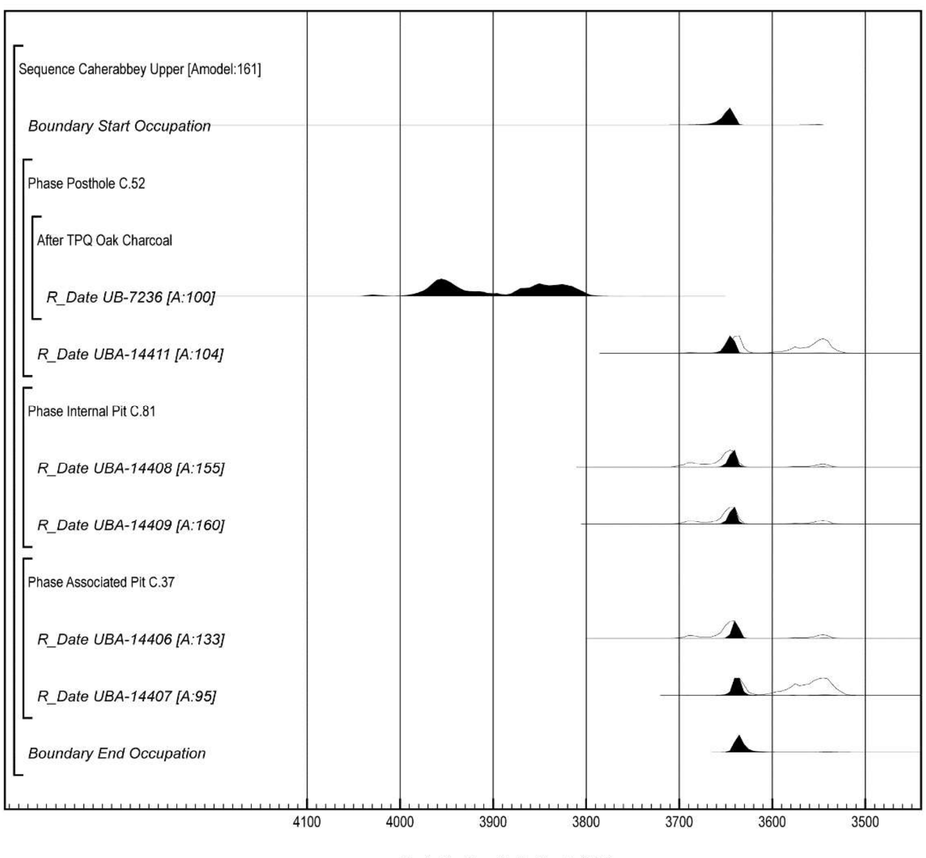

Figure B.28 Bayesian model for occupation at Caherabbey Upper (site 185.1-4)

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 160.6 Aoverall 162.1		
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	C
Sequence Caherabbey Upper															
Boundary Start Occupation							-3655	-3640	68.2	-3682	-3549	95.4			97.9
Phase Post-hole C.52															
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4									
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.6	99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3651	-3640	68.2	-3663	-3634	95.4		104	99
Phase Internal Pit C.81															
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3648	-3639	68.2	-3656	-3633	95.4		155.4	99.7
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3648	-3639	68.2	-3655	-3633	95.4		160.2	99.7
Phase Associated Pit C.37															
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3645	-3635	68.2	-3651	-3629	95.4		132.8	99.9
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3644	-3634	68.2	-3651	-3625	95.4		95.4	99.5
Boundary End Occupation							-3643	-3630	68.2	-3651	-3536	95.4			98.7

Table B.11 Bayesian model for occupation at Caherabbey Upper (site 185.1-4)

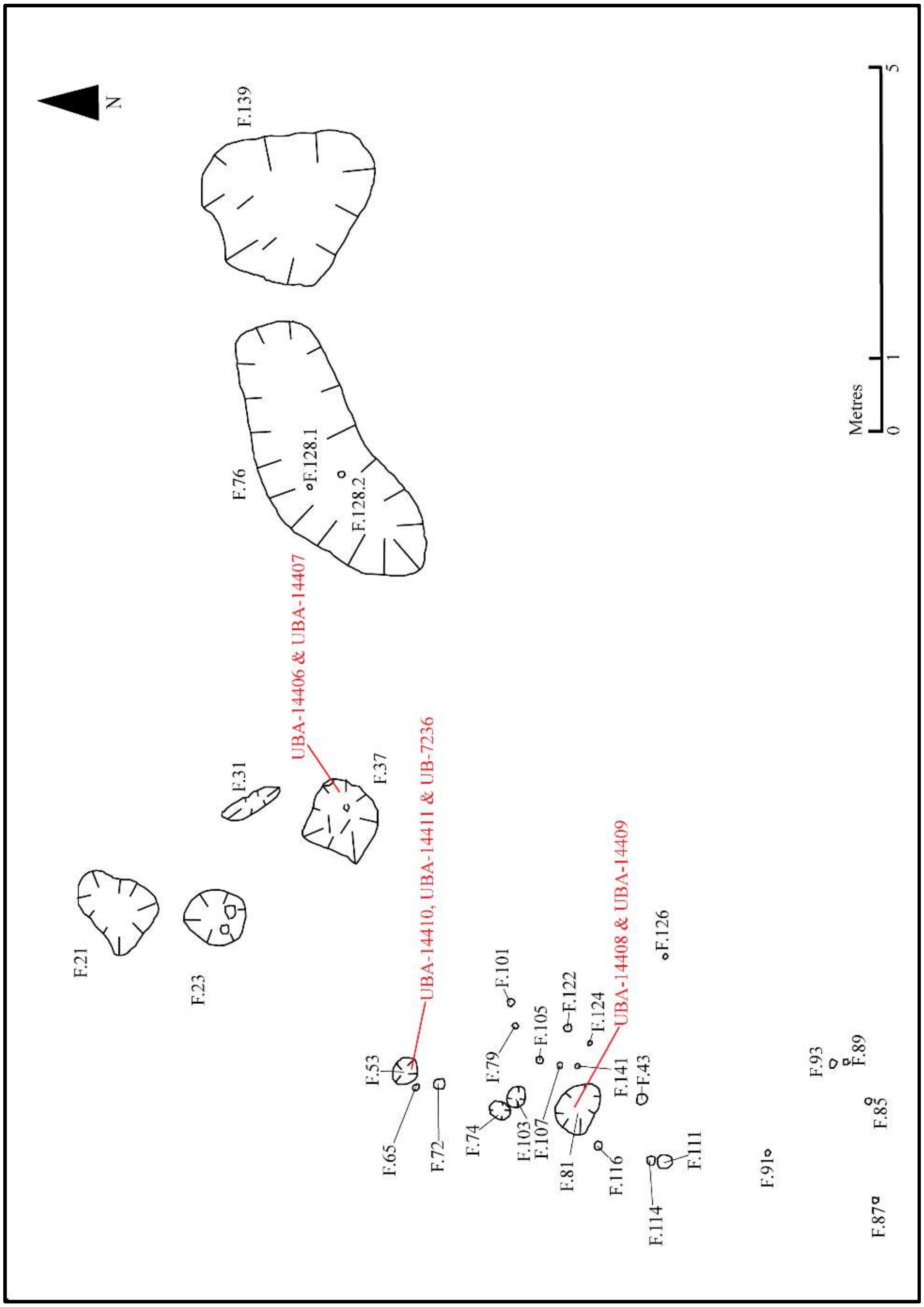

Figure B.29 Neolithic features from Area 1, Caherabbey Upper (site 185.1-4)

(23) Townland: Caherdrinny (site 3)
Barony: Condons and Clangibbon
County: Cork
Site Type: Neolithic rectangular houses and associated features
SMR: N/A
Excavation Licence Number: E2422
ITM: 580314, 608211
National Grid: 180360, 108157
OD: 150m
Reference: (Bower *et al.* 2011)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between February and August 2007.

Structure 1

A large rectangular house (Structure 1) and associated occupation material was located in the central part of the site. A concentration of features was located in the environs of the house, in particular to the south. Structure 1 measured 10.1m long by 7m (external dimensions) and 8m by 5.7m (internal dimensions). The long-axis of the building was aligned north-east to south-west. The structure was represented by a foundation trench that would have held planks and posts. The building was rectangular in plan.

Foundation trench

The foundation trench C.410 defined the entire perimeter of the building. Two main fills were recorded within the foundation trench (C.411 and C.838). The primary fill (C.411) was a brown silt with frequent lumps of burnt clay and charcoal and included sherds of pottery, lithics, flecks of indeterminate burnt animal bone and hazelnut shells. The packing fill (C.838) was located mostly on the site of the foundation trench. Sherds of prehistoric pottery were recovered from the fills of the trench and the post-holes.

The northern wall

The northern wall measured 9.5m in length and was relatively uniform in width measuring on average 0.7m. One post-hole (C.1002) was identified within the northern foundation trench. Four external post-holes (C.472, C.877, C.939 and C.978) and one stake-hole (C.1016) were located to the north of the wall. Charcoal from one of the external posts (C.877) was dated to the Early Neolithic.

The western wall

The western wall measured 7.3m in length. A large stone (C.985) was located at the north-western corner. Seven post-holes (C.899, C.972, C.980, C.991, C.995, C.1010 and C.1056) were recorded within the foundation trench and six of them were set in pairs. Flecks of indeterminate burnt animal bone were recovered from the fill of the southern corner post (C.991). One external post C.947 was located outside the foundation trench opposite post C.972. Flecks of indeterminate burnt animal bone were recovered from the fill of the southern corner post (C.991). A flint flake and a sherd of pottery were recovered from one of the fills (C.936) of the foundation trench. Three posts (C.844, C.862 and C.872) were located 0.5m west of the north-western corner. They may have supported the north-west corner or been part of a fence line.

The southern wall

The southern wall measured 8.9m in length. One post-hole (C.1030) was located mid-way on the length of the foundation trench. Five external post-holes (C.822, C.871, C.921, C.955 and C.974) were located to the south of the wall.

The eastern wall

The foundation trench was continuous on the north, west and south sides but was interrupted in the north-eastern corner. This was the area of the entrance, though the gap was very narrow being only 0.2m wide. It was flanked on the southern side by a large post-hole C.946. There were no external post-holes on this side of the foundation trench. Sherds of Early Neolithic pottery were recovered from two fills of the trench (C.992 and

C.996). Two fragments of flint debitage and a flint flake were recovered from a fill of the post-hole C.946.

Internal features

Two substantial post-holes or portions of slot trenches (C.886 and C.892) were located mid-way within the interior of the house. They were orientated NW/SE perpendicular to the main axis of the house and indicate the location of an internal division within the house. They were aligned with two posts to the south, one within the foundation trench and one on the exterior (C.1030 and C.974). Flint debitage was recovered from a fill of the trench. Three small post-holes (C.905, C.928 and C.1027) were located in the NW corner of the house. A flint flake was recovered from a fill of C.905. A short length of slot trench C.898 was located at the eastern end of the house and was set at an acute angle to the eastern wall. Sherds of pottery (Vessels were recovered from the fill of the trench. A pit C.973 cut the slot trench, charcoal from the pit was dated to Early Neolithic. A sherd of pottery was recovered from the pit.

Hearths

There was no internal hearth in Structure 1, but two external hearths were located to the east and south of structure 1. C.820 was located 2.5m east of the house and was cut by three stake-holes (C.826, C.828 and C.830). Charred plant remains were recovered from one of the fills of the hearth. A second hearth C.832 was located 2.7m south of structure 1 and 5.5m south-west of hearth C.820. Three stake-holes (C.835, C.845 and C.837) were located on the southern edge of the hearth. Charred plant remains were recovered from the fill of the hearth. A third hearth C.1375 was located *c.*8m to the north-east of the house. A total of five stake-holes (C.1372, C.1377, C.1379, C.1384 and C.1386) were associated with the hearth. No plant remains were recovered from the hearth.

Structure 2

An L-shaped structure was located 10m to the south-west of structure 1. It measured 3.2m long by 2.4m wide and comprised at least ten post-holes (C.587, C.636, C.646, C.679, C.688, C.694, C.744, C.746, C.1089 and C.1091) and 13 stake-holes (C.605, C.619, C.634, C.648, C.650, C.652, C.654, C.656, C.681, C.764, C.786, C.796 and C.1113). The combination of posts and stakes formed the eastern and southern sides of a structure or shelter. An Early Neolithic date was obtained from one of the posts (C.636). A group of 12 stake-holes (C.797, C.803, C.805, C.1117, C.1141, C.1145, C.1147, C.1159, C.1166, C.1183, C.1185 and C.1234) and eight post-holes (C.779, C.787, C.801, C.1115 and C.1125, C.1164, C.1168 and C.1236) curved to the north-west beyond structure 2. They may have formed an extension to the eastern side of the structure/shelter. An irregular pit or slot trench C.1228 was located in the middle of the group. Four post-holes (C.810. C.812, C.1074 and C.1077) and a pit C.807 were located 1.8m west of or inside structure 2. Eight stake-holes (C.700, C.702, C.704, C.706, C.1269, C.1271, C.1277 and C.1279) were set in a semi-circular pattern 2m to the north of the alignment of posts and stakes.

Activity located to the north of structure 2

A group of two small pits (C.1248 and C.1573), five post-holes (C.917, C.1206, C.1250, C.1256 and C.1287), 12 stake-holes (C.908, C.911, C.929, C.937, C.940, C.1226, C.1265, C.1273, C.1275, C.1283, C.1289 and C.1583) and two linear features (C.1296 and C.1357) were located to the north-east of the semi-circular arrangement of stakes. Sherds of Early Neolithic pottery were recovered from two of the stake-holes (C.1226 and C.1289) and one of the linear features (C.1357). The second linear feature (C.1296) was located 1.4m to the south-east. A line of six stake-holes (C.718, C.720, C.722, C.724, C.726 and C.728) forming a wind-break or a screen were located 4m to the west of the semi-circular arrangement of stakes. Three stake-holes (C.712, C.714 and C.716) which formed a V-shaped tripod were located to the immediate south of the line. A substantial post-hole (C.499) was located on the edge of the area of excavation 10m west of structure 2, sherds of Early Neolithic pottery and Middle Bronze Age domestic cordoned urn were recovered from the fill C.500 of post C.499.

Activity located to the south of structure 2

A large rectangular pit C.451 was aligned NW–SE and measured 4.19m by 2.50m by 0.20m in depth. Three lithics, flint debitage and two rubbing/hammer stones, dated to the Early Neolithic, were recovered from the fill. Prunus charcoal from the same fill was dated to the Middle Bronze Age which suggests that all the artefacts were re-deposited.

Pit C.301/303 was located 1m to the north-west of pit C.451. A flint core dated to the Middle Neolithic was recovered from the fill of pit C.301. A group of features that comprised seven pits (C.312, C.324, C.388 C.515, C.517, C.527 and C.535), three post-holes (C.322, C.328 and C.540), four stake-holes (C.520, C.617, C.624 and C.629) and a hearth C.336 were located on the south-western side of pit C.451. A pit C.527 was located immediately west of the pit C.451. Four sherds of Early Neolithic pottery and three fragments of flint debitage a were recovered from the upper fill C.526. A fragment of quartz crystal debitage dated to the Early Neolithic and two sherds of Early Neolithic pottery were recovered from basal fill C.539. The southern side of the pit cut a post-hole C.540, a sherd of Early Neolithic pottery was recovered from the fill of the post. A hearth C.336 was located 1m south-west of pit C.527. The base was burnt *in situ*. A total of 18 fragments of burnt animal bone were recovered from the hearth. Five of the bones belonged to a large-sized mammal such as cattle, the remaining fragments were indeterminate as they were totally calcined. A single grain of wheat was also recovered. Three stake-holes (C.617, C.624 and C.629) located 2.7m to the west may have formed a wind break to shelter the hearth. A group of three pits (C.312, C.324 and C.515) and two post-holes (C.322 and C.328) were located to the south-east of the hearth. A foundation trench C.278 was located 3.5m south-east of pit C.451. The base of the trench was cut by two stake-holes (C.338 and C.384), both were located in the widest parts of the trench. Two pits (C.346 and C.354) cut the south-eastern end of the trench. A flint blade and a sherd of Neolithic pottery was recovered from the pit C.354.

Ceramics

An assemblage of 284 sherds representing up to 33 vessels was found at Caherdrinny (site 3). Sherds came from the topsoil (C. 1, 983), a deposit (C. 553), burnt soil (C. 929, 936), a number of pits (C.287, 454–456, 476, 539, 541, 566, 580, 593, 824, 868, 878, 890, 901, 990, 1625), the slot trench of house (C. 277, 411, 897, 903, 935, 975, 1366), post-holes (C. 486, 500, 696, 891, 920, 924, 945, 950, 952–53, 960, 990, 996, 1006, 1038, 1358), stake-holes (C. 526, 944, 947, 1227, 1253, 1290, 1324, 1628) and a hearth (C. 838). This material represents domestic activity. The pottery sherds have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

Two-hundred-and-twenty-three lithic finds from the archaeological excavations of a prehistoric site in the townland of Caherdrinny 3. Thirteen cores derive from the topsoil, a slot trench and various pit fills. Only four of the thirteen cores are made of flint, the remaining 9 cores are made of quartz crystal. All but two cores were reduced using a bipolar method. Almost fifty percent of the 50 flakes were excavated from the topsoil or subsoil. The remaining flakes derive from various pit fills (most notably from C.287, C.553 and C.580), post-hole fills and the fill of a linear feature (c.2063). 48 flakes are made of flint and 2 are made of quartz. Three miscellaneous artefacts include a strike-a-light and a concave scraper. The majority of the artefacts are associated with the early Neolithic house and its environs. The presence of 97 pieces of debitage and the occurrence of cortical flakes and cores as well as the presence of refitted artefacts indicate that knapping took place at the site.

Archaeobotanical remains

Charred plant remains were recovered from 23 samples in deposits associated with the Early Neolithic house. Only a small quantity of plant remains was recovered from these samples. These included fragments of hazelnut shells and some fruit seeds (raspberry/blackberry seeds and apple/pear pips). Cereals included 17 unidentifiable cereals and 7 other grains that were classified as oat and emmer wheat. Plant remains were recovered from 69 samples in the area around the Early Neolithic house. In these features there was a much lower incidence of hazelnut shell retrieval, and much larger quantities of cereals were recovered.

Archaeozoological remains

Slot trench (C.410) of structure 1 produced a small sample of nine indeterminate fragments of burnt bone. The fill of a post-hole (C.991) associated with the house also contained tiny amounts of indeterminate bone. Hearth (C.336) produced eighteen fragments of burnt animal bone, but none of these can be identified due to the totally calcined nature of the material. Five bones are sufficiently large to indicate that they belong to a large-sized mammal such as cattle, the remaining fragments are indeterminate.

Radiocarbon dating

Four Early Neolithic radiocarbon dates were obtained from the excavation at Caherdrinny (site 3) (see Table B.12). Two were associated with structure 1, *Prunus* spp. charcoal from fill C.957 of internal hearth C.973 returned a date range of 4034-3808 cal BC, and hazel charcoal from fill C.878 of post-hole C.877 returned a date range of 3766-3650 cal BC. Hazel charcoal from fill C.637 of post-hole C.636 of structure 2 returned a date range of 4054-3936 cal BC and hazel charcoal from fill C.210 of hearth C.294 returned a date range of 3701-3638 cal BC.

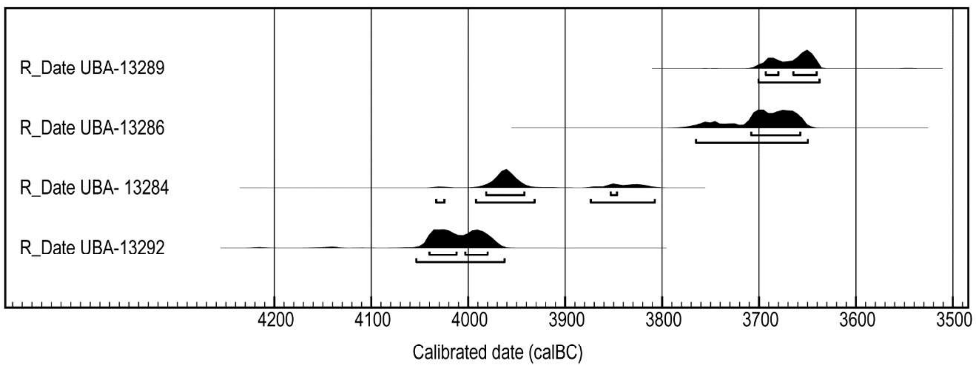

Figure B.30 Calibrated radiocarbon dates from Caherdrinny (site 3)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-13289	C.294	Hazel Charcoal	4877±26	3701-3638 cal BC	3694-3680 cal BC (19.0%) 3665-3641 cal BC (49.2%)
UBA-13286	C.877	Hazel Charcoal	4926±26	3766-3650 cal BC	3708-3585 cal BC
UBA-13284	C.973	Prunus Charcoal	5138±27	4034-4025 cal BC (1.2%) 3992-3932 cal BC (70.1%) 3874-3808 cal BC (24.1%)	3982-3942 cal BC (64.5%) 3854-3847 cal BC (3.7%)
UBA-13292	C.636	Hazel Charcoal	5214±27	4054-3963BC (95.4%)	4040-4012 cal BC (38.1%) 4004-3980 cal BC (30.1%)

Table B.12 Calibrated radiocarbon dates from Caherdrinny (site 3)

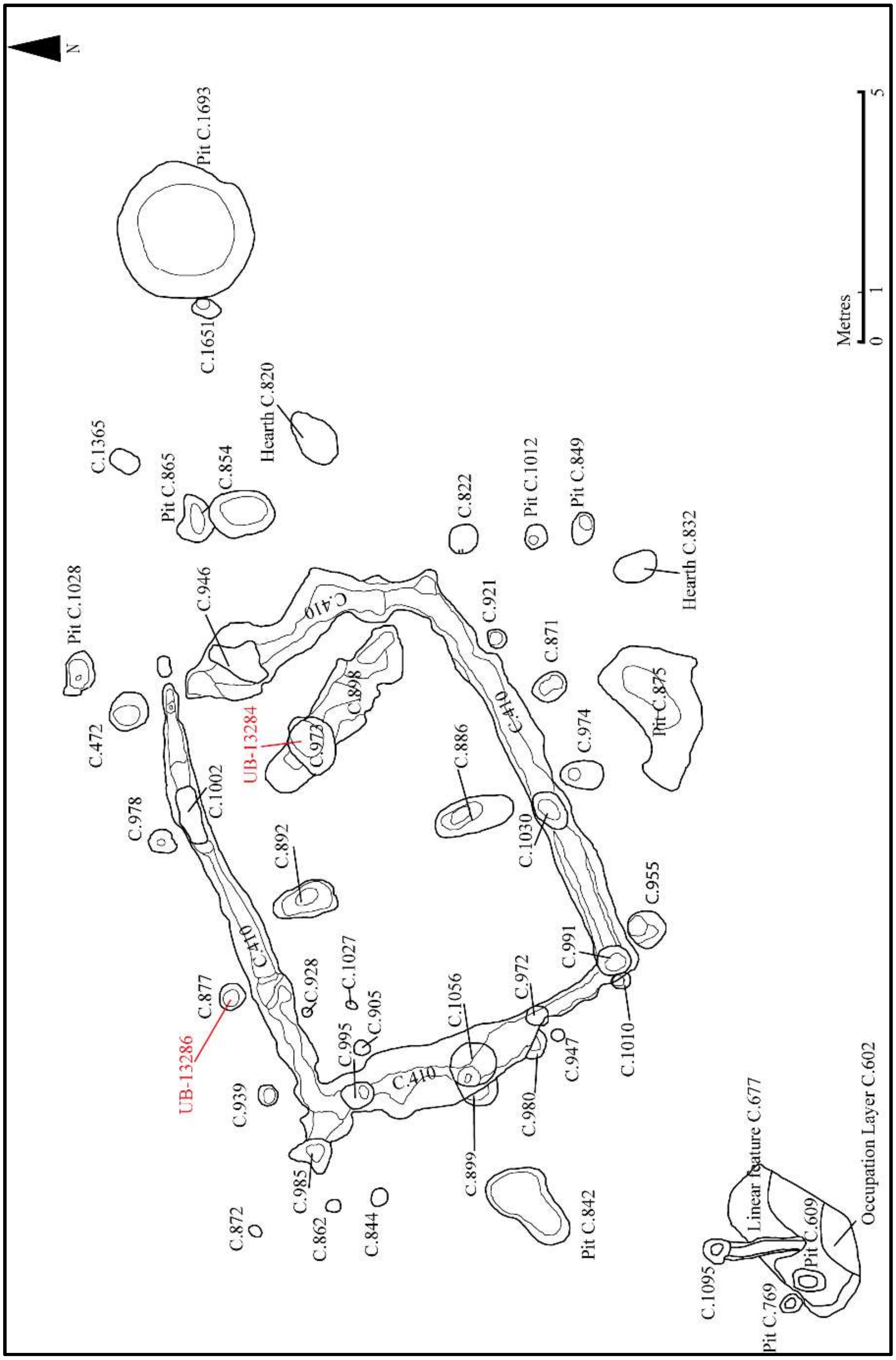

Figure B.31 Structure 1 Caherdrinny (site 3)

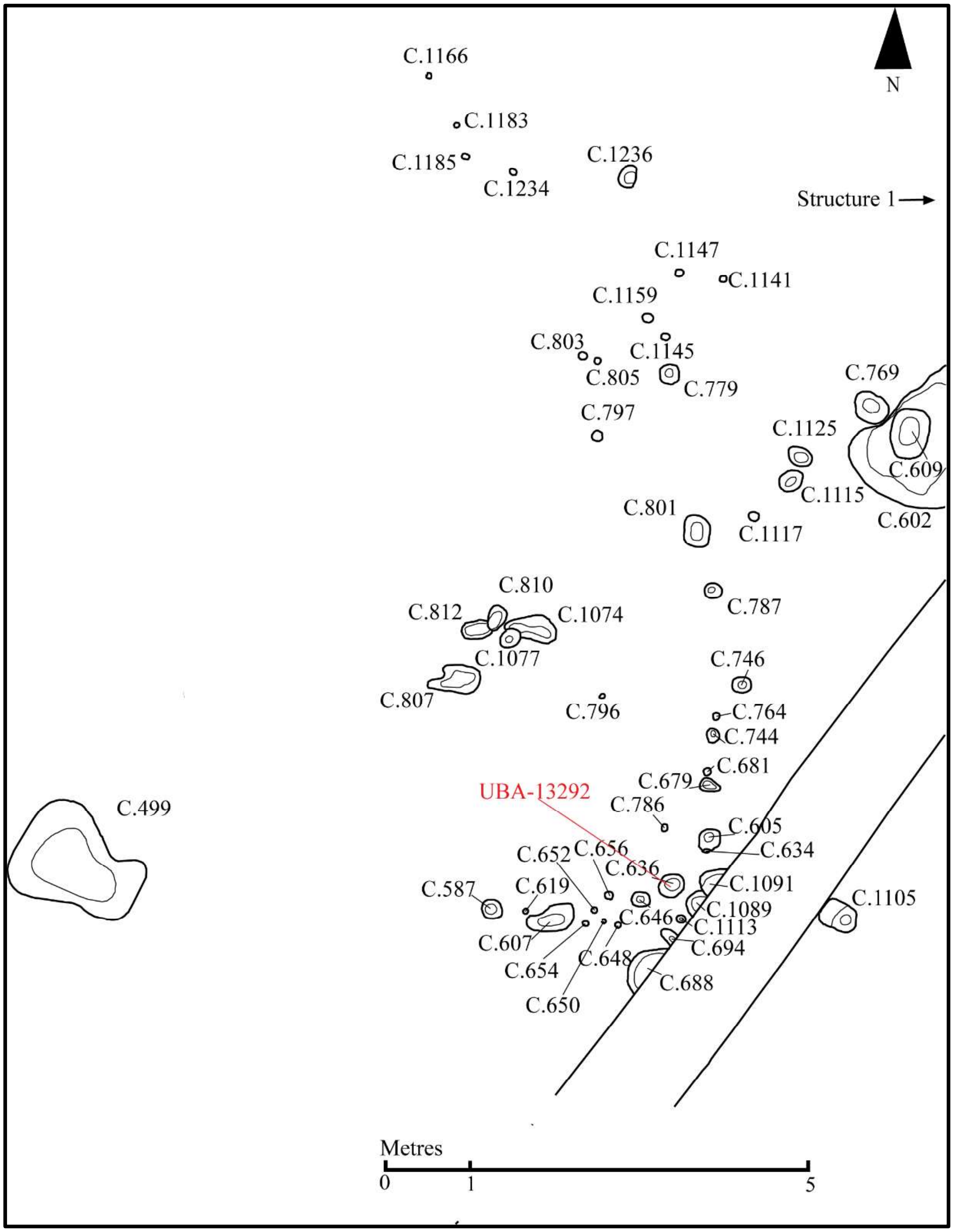

Figure B.32 Structure 2 Caherdrinny (site 3)

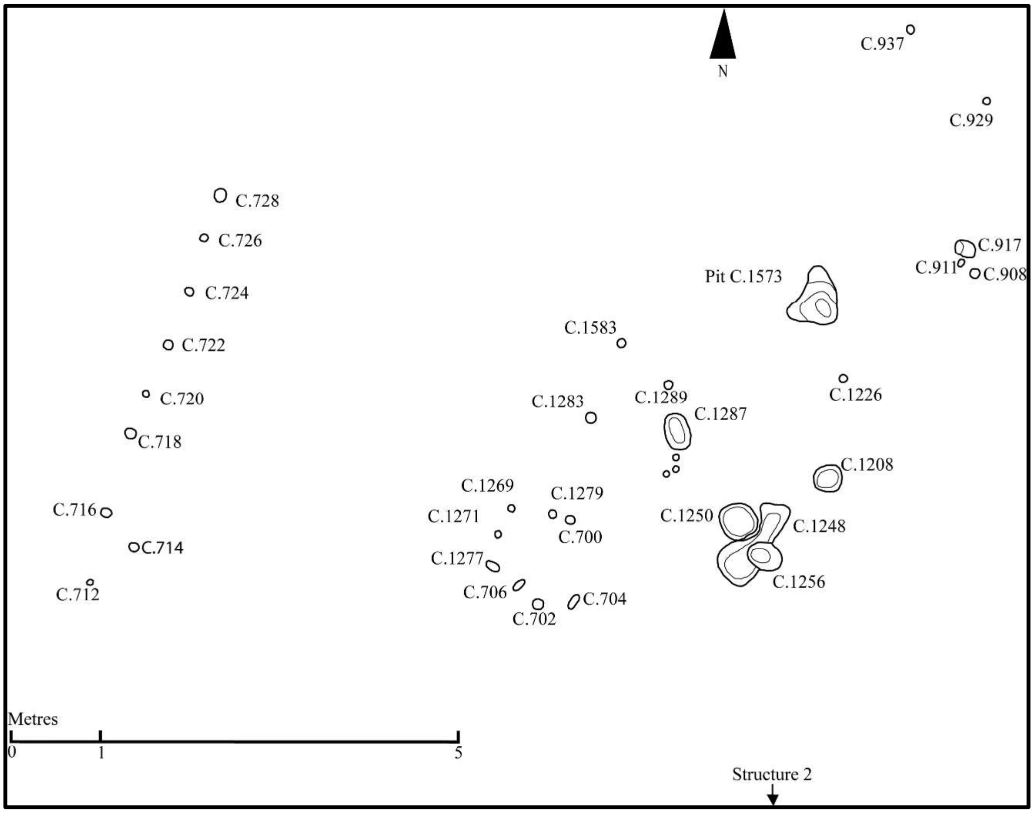

Figure B.33 Neolithic features to the north of structure 2, Caherdrinny (site 3)

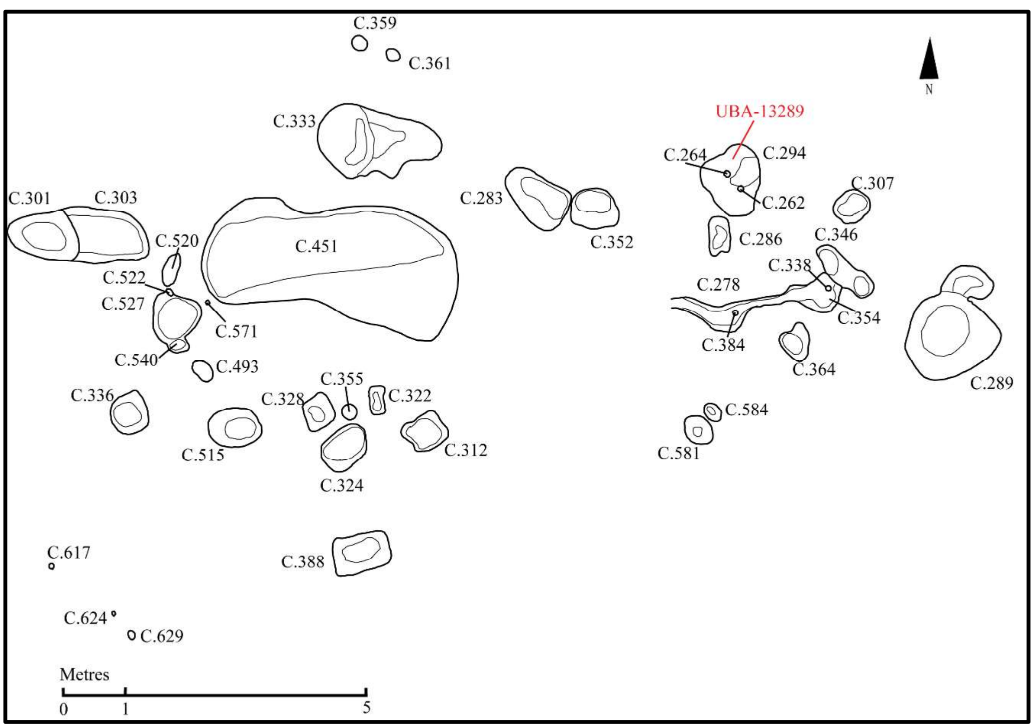

Figure B.34 Neolithic features to the south of structure 2, Caherdrinny (site 3)

(24) Townland: Castleblagh (Claidh Dubh)

Barony: Fermoy

County: Cork

Site Type: Trackway

SMR: CO018-001----

Excavation Licence Number: 93E0122

ITM: 570564, 598235

National Grid: 170608, 98179

OD:

Reference: (Doody 1995; 2008)

A well-preserved trackway, 2.1m wide by 0.18-0.2m thick and sealed beneath 0.16m of peat was recorded during excavation of the Claidh Dubh linear earthwork as part of the *Ballyhoura Hills Project* funded by the Discovery Programme. The surface comprised small stones set in a peaty matrix and appeared to have been constructed within a hollow which had been dug out of the B/C horizon.

Radiocarbon dating

An early Neolithic date range of 3941-3661 cal BC was returned for the peaty matrix into which the stone had been set (see Table B.13). A second peat sample from above the trackway returned a date range of 139-250 cal AD (*UB-3721,* 1801±39 BP) and can be treated as a *terminus ante quem* for construction of the trackway.

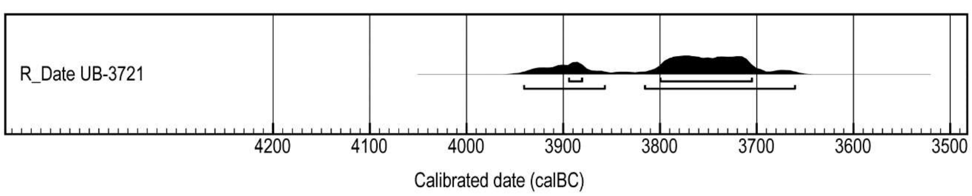

Figure B.35 Calibrated date from Castleblagh, Claidh Dubh

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-3722	Peaty matrix	Peat	4991±41	3931-3858 cal BC (22.6%) 3816-3661 cal BC (72.8%)	3895-3881 cal BC (6.0%) 3800-3706 cal BC (62.2%)

Table B.13 Calibrated date from Castleblagh, Claidh Dubh

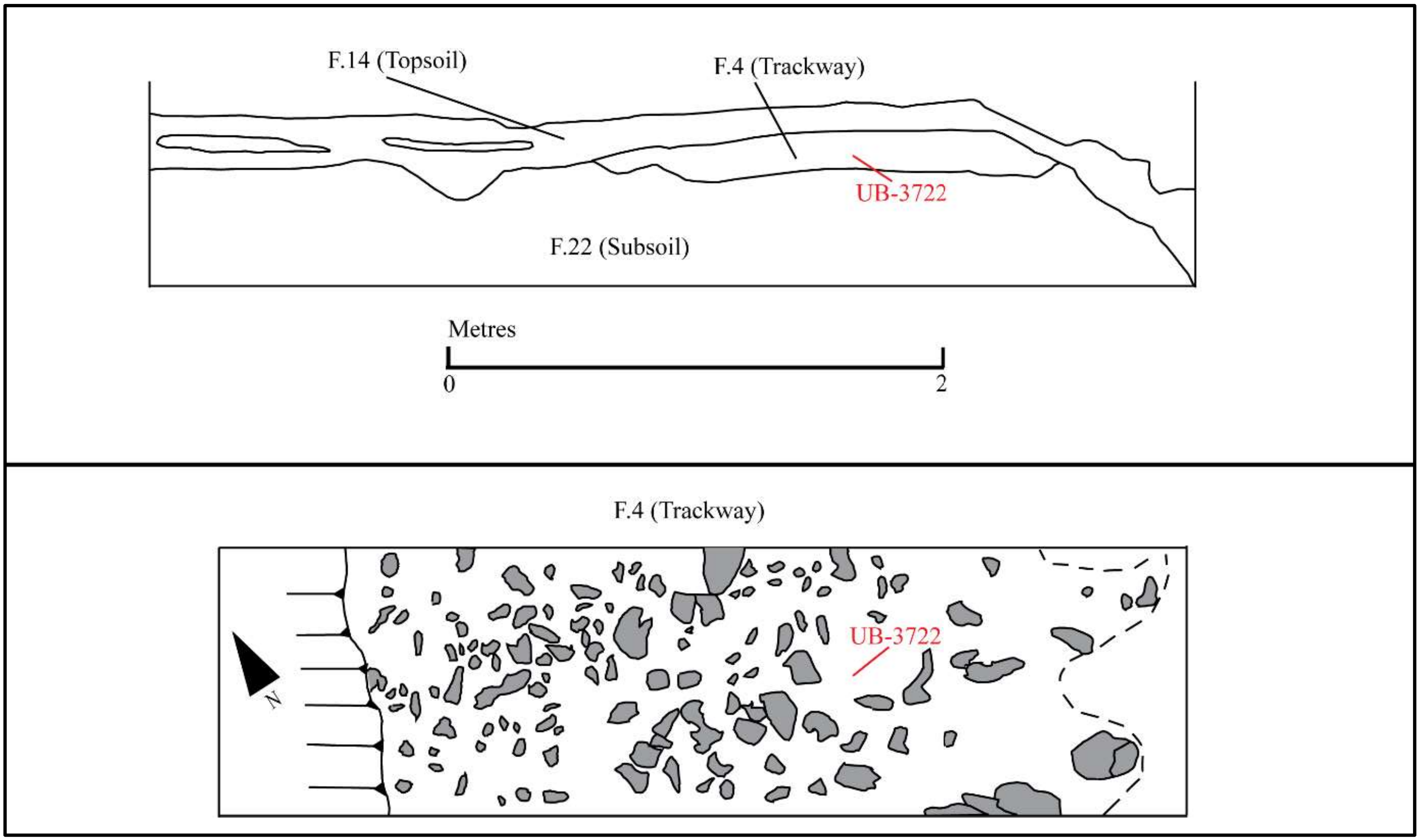

Figure B.36 Trackway from Castleblagh, Claidh Dubh

(25) Townland: Cloghers

Barony: Trughanacmy

County: Kerry

Site Type: Neolithic Rectangular House

SMR:

Excavation Licence Number: 98E0238

ITM: 483510, 613267

National Grid: 83534, 113213

OD: 17m

Reference: (Kiely 1999; 2003; Kiely and Dunne 2005)

Excavation in advance of a housing development at Cloghers, County Kerry uncovered the remains of a rectangular structure. The structure measured 7.8m by 13m externally, with two external walls creating a tripartite layout. The site had been truncated by a series of cultivation furrows which completely eroded the foundation trench in the north-west corner. The outline of the structure consisted of the remains of for external walls with two internal walls at the eastern and western end of the structure. The northern and eastern walls were constructed from stakes and posts set in a substantial trench, while the southern and western walls were constructed from narrow slot trenches which likely supported split planks. A fence line was identified 1m to the south of the house, while a large pit and concentration of post-holes and smaller pits were excavated to the east of the structure. No evidence of a floor or hearth was recorded.

Ceramics

The pottery assemblage consisted of 125 sherds representing at least 9 vessels and have been identified as coming from Early Neolithic Carinated Bowls which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. Also identified during excavation were lumps of clay, suggesting pottery production was undertaken on site.

Lithics

A large lithic assemblage included greenstone axe fragments, a flint arrowhead base, flint scrapers, limestone beads, quartz, chert, mudstone hammer stones and greenstone axe production debitage.

Archaeobotanical remains

The plant remains recovered at Cloghers included barley, bread-wheat, oats, possibly spelt wheat and hazelnuts shells. The typical Neolithic wheats, emmer and einkorn were not identified at Cloghers. The occurrence of oat grains is unusual and may be construed as intrusive or as cultivation weeds.

Archaeozoological remains

A small faunal assemblage of 190 fragmentary bones was recovered, 20 of which could be identified to species. The majority of these were recovered from pit C.237, interpreted as a cooking pit. These included cattle, sheep/goat, probable hare and three fragments of small perching birds in addition to numerous unidentifiable mammal bones.

Radiocarbon dating

Two radiocarbon dates were obtained for the structure at Cloghers (see Table B.14). Charred hazelnut shells from the basal fill of the western internal wall returned a date range of 3708-3527 cal BC, while charred hazelnut shells from the fill of the northern wall returned a date range of 3768-3638 cal BC.

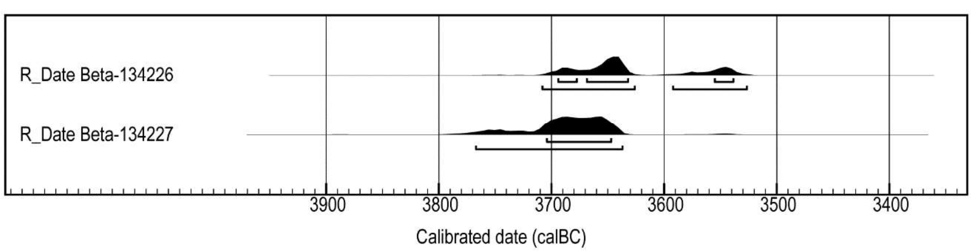

Figure B.37 Calibrated radiocarbon dates from Cloghers

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
Beta-134226	Western internal wall	Hazelnut Shell	4850 ± 40	3708-3626 cal BC (69.3%) 3592-3527 cal BC (26.1%)	3694-3678 cal BC (11.2%) 3669-3632 cal BC (45.1%) 3556-3539 cal BC (11.9%)
Beta-134227	Northern wall	Hazelnut Shell	4900 ± 40	3768-3638 cal BC	3704-3648 cal BC

Table B.14 Calibrated radiocarbon dates from Cloghers

(26) Townland: Cool west

Barony: Iveragh

County: Kerry

Site Type: Field system

SMR: KE087-006----

Excavation Licence Number:

ITM: 436136, 575482

National Grid: 36150, 75420

OD:

Reference: (Mitchell 1989)

The site is located towards the northern end of the Imlagh Basin, Valencia Island. A poorly preserved stretch of wall emerges from the base of a *c.*1.5m high peat-face and runs east-northeast by west-southwest for *c.*6m. It is composed of small stones and intermittent uprights and was constructed on Phragmites peat, *c.*2m in depth.

Radiocarbon dating

An early Neolithic date range of 3771-3346 cal BC was returned for willow twigs into which found at the level of the base of the stone wall (see Table B.15).

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
I-14206	Base of wall	Willow twigs	4760±100	3771-3346 cal BC	3644-3498 cal BC (50.5%) 3436-3378 cal BC (17.7%)

Table B.15 Calibrated date from Cool West

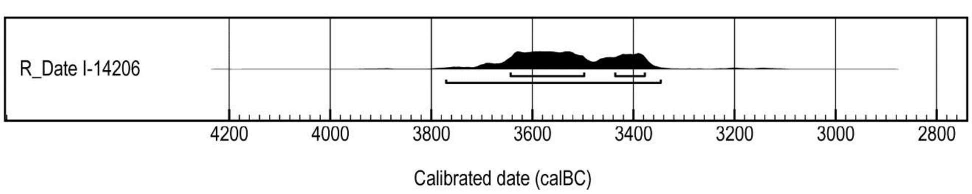

Figure B.38 Calibrated date from Cool West

(27) Townland: Cooltubbrid East

Barony: Decies without Drum

County: Waterford

Site Type: Pits (residual pottery finds)

SMR:

Excavation Licence Number: 00E0059

ITM: 639411, 605225

National Grid: 239469, 105170

OD: 210m

Reference: (Tierney 2003; 2008)

The site was identified in advance of road works on the N25 Kilmacthomas realignment. The site consisted of a Late Bronze Age circular structure and associated pit features. However, a quantity of Early Neolithic pottery was also recovered throughout the site. The widespread retrieval of Early Neolithic pottery suggests that the Late Bronze Age occupation disturbed earlier habitation use.

Ceramics

Much of the pottery discovered outside the circular structure has been identified as coming from at least five Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. The majority of the vessel fragments are found in features located in the north of the site. Vessel 1 was found in fill 133 of post-hole 134, sherds were also found in fills of stake hole cut 123 and post-hole 237. Vessel 2 was found in context 340, part of the area of root disturbance or hedging. Sherds of Vessel 3 were found in four contexts; the fill of post-hole 148, in Context 533 the hedge or area of plant disturbance, the fill of post pipe cut 113 and the fill of stake hole 214. Cut 113 contained pottery dated to the Early Neolithic and the Bronze Age. Vessel 4 was found in post-hole 237 (with part of Vessel 1) and postpipe 113 (with parts of Vessel 3). Vessel 5 was found in a number of deposits, contexts 101, 223 and 505 in the large stone lined pit 771. Vessel 5 dated to the Early Neolithic was found in association with Vessel 6 that was identified at Late Bronze Age in date. As the large pit 771 and the post-hole 113 had Neolithic and Bronze Age pottery deposited together in well-sealed stratigraphic units, this suggest the Neolithic pottery may have been redeposited in the Late Bronze Age.

(28) Townland: Coonagh West

Barony: North Liberties

County: Limerick

Site Type: Lithic findspot

SMR:

Excavation Licence Number: E2091

ITM: 553260, 656919

National Grid: 153300, 156876

OD: 0.5-2m

Reference: (Taylor and Ruttle 2013; Bermingham *et al.* 2013)

Although no cut features have been assigned to the Neolithic, evidence of activity during the period is provided by the presence of artefacts of this date. Some of these artefacts were found in alluvial deposits beneath Bronze Age features to the south of the site. No radiocarbon dates from the Neolithic were returned, but Neolithic activity is identified by the lithic assemblage.

Lithics

Two deposits (C.1351 and C.1356) produced small stone axeheads. An Early Neolithic chert leaf-shaped arrowhead, Neolithic flint blade and number of pieces of chert flakes were recovered from alluvial deposit C.1255. Deposit C.1080 produced five cores, twelve pieces of debitage, sixteen flakes, six blades, two arrowheads and three scrapers. Also, from deposit 1080 was a large stone axe which is thought to be Mesolithic or more likely Neolithic in date. Numerous lithic items from the site surface (C.1462) and topsoil (C.50) include Neolithic tools such as an unfinished leaf-shaped arrowhead, a plano-convex knife and a possible hollow scraper blank. A later pit (C.910) also produced a lozenge-shaped arrowhead.

(29) Townland: Corrin (site 1)

Barony: Barrymore

County: Cork

Site Type: Pits and associated features

SMR:

Excavation Licence Number: 03E0912

ITM: 581239, 595421

National Grid: 181285, 095364

OD: 219m

Reference: (O'Connell 2006; 2013)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between August and October 2003. In the course of excavations, a number of external features were recorded to the north of the enclosure. These included three pits (C.106, C.108 & C.121), seven post-holes (C.61, C.65, C.73, C.75, C.94, C.117 & C.119) and nineteen stake-holes (C.51, C.53, C.55, C.59, C.63, C.67, C.69, C.77, C.81, C.86, C.90, C.92, C.98, C.100, C.102, C.104, C.111, C.113 & C.115). Oak charcoal from pit C.121 returned an Early Neolithic date range. No distinct spatial patterns representative of any structural type was recognised but these features may represent Early Neolithic settlement. It is possible that further Neolithic features may be located outside the road corridor to the north of the enclosure. No diagnostic Neolithic artefactual remains were recovered during excavation.

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation at Corrin (site 1) (see Table B.16). Oak charcoal from pit C.121 returned a date range of 3968-3794 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Beta-201027	C.121	Oak Charcoal	5090 ± 40	3968-3794 cal BC	3958-3930 cal BC (18.5%) 3876-3805 cal BC (49.7%)

Table B.16 Calibrated radiocarbon date from Corrin (site 1)

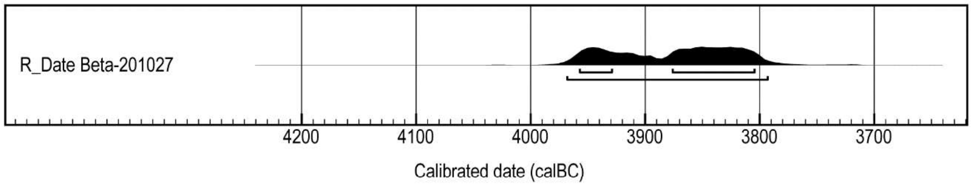

Figure B.39 Calibrated radiocarbon date from Corrin (site 1)

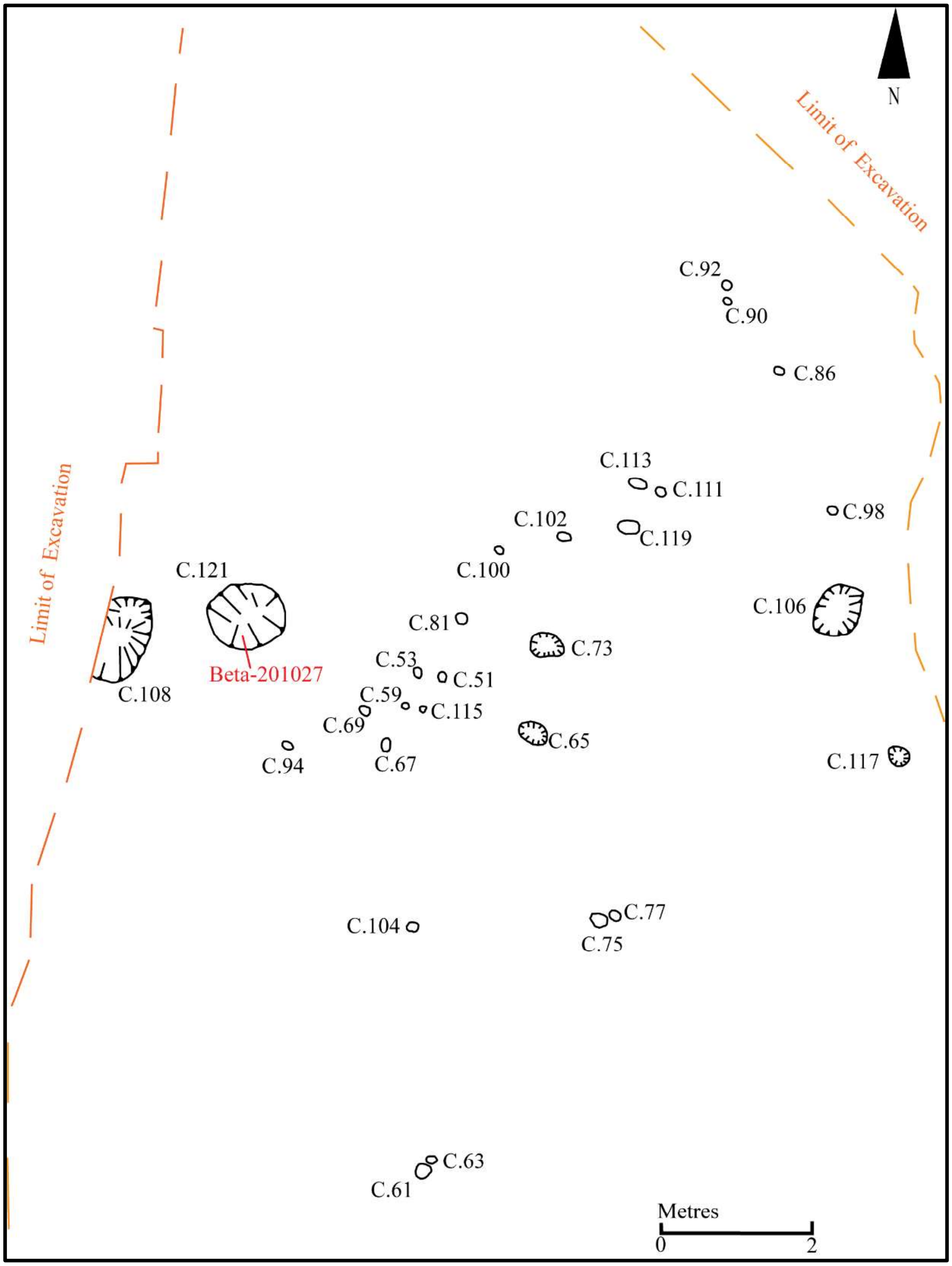

Figure B.40 Neolithic features from Corrin (site 1)

(30) Townland: Curraghprevin (site 3)

Barony: Barrymore

County: Cork

Site Type: Pit group

SMR:

Excavation Licence Number: 03E1138

ITM: 579052, 589305

National Grid: 179098, 089247

OD: 96-98m

Reference: (O'Neill 2006; 2013)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated in July 2003 Two pits, F.27 and F.58 were located adjacent to each other and west of the site. Six fragments of Neolithic pottery were retrieved from pit F.27. A cluster of three pits F.49, F.50, F.51 were located to the north of pits F.27 and F.58. The pit F49 was located northeast of F50 and east of F51. Radiocarbon analysis of charcoal from pit F.49 returned a Late Neolithic date range. Finds from this feature included Neolithic pottery, hazelnut shells and flint microliths. The adjacent pit F50 was associated. Finds from this feature included Neolithic pottery, hazelnut shells and flint flakes. The pit F51 was located northwest of F50. Finds from this feature included Neolithic pottery, hazelnut shells, flint fragments and a crystal fragment. Pit F.44 was located to the east of pits F.49, F.50, and F.51. Radiocarbon analysis of charcoal retrieved from this pit revealed a Neolithic date range. Finds from this pit included a possible hammerstone, three flint flakes, a quartz flake and Neolithic pottery.

Ceramics

The site produced a small assemblage of Early Neolithic pottery. There are 74 sherds from at least four vessels. Vessels 1 (from pits F.50, F.51 and F.44), 2 and 3 (both from F.49) were identified as modified carinated bowls (Sheridan 1995, 7). Vessel 4, from pit F.27, was identified as an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. While Vessels 1-3 represent a stylistic development from the simpler forms represented by Vessel 4 it is probable that all four pots were in contemporary use; it has been suggested that modified pottery with developed rims and shoulders could have emerged at a very early date at Donegore Hill, Co. Antrim (Mallory and Hartwell 1984; Sheridan 1995).

Lithics

The lithic assemblage associated with Curraghprevin (site 3) indicates that tool manufacture was being carried out within the area of the site. The assemblage contains 43 pieces of debitage flakes (from pits F.44, F.49, F.50 and F.51). The assemblage also contains one leaf shaped arrowhead (F.49), a possible hammerstone (F.44) and a hone stone/wet-stone (F.49). Five microlithics were also recovered from pit F.44. The assemblage also contains two river rolled stones which appear to be natural and contain no visible signs of use.

Archaeobotanical remains

Charred plant remains were recovered in the from three contexts at Curraghprevin (site 3). Hazelnut fragments were recovered from pits F.49, F.50 and F.51.

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation at Curraghprevin (site 3) (see Table B.17). Charcoal from pit C.44 returned a date range of 3651-3356 cal BC. A Late Neolithic date range (*Beta-201070*, 4260±100 BP) was also returned from charcoal recovered from pit F.49, however this is likely to be a later inclusion as it was recovered from a context with diagnostically Early Neolithic material.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Beta - 201069	F.44	Charcoal	4720 ± 80	3651-3356 cal BC	3632-3561 cal BC (25.0%) 3537-3497 cal BC (14.5%) 3456-3377 cal BC (28.6%)

Table B.17 Calibrated date from Curraghprevin (site 3)

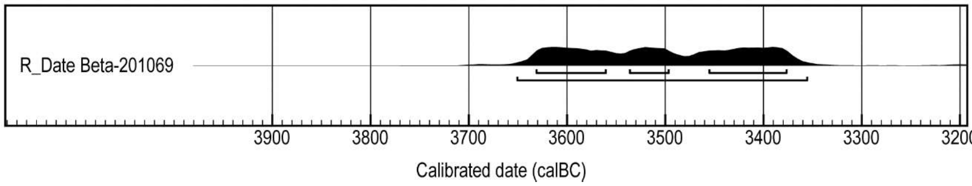

Figure B.41 Calibrated date from Curraghprevin (site 3)

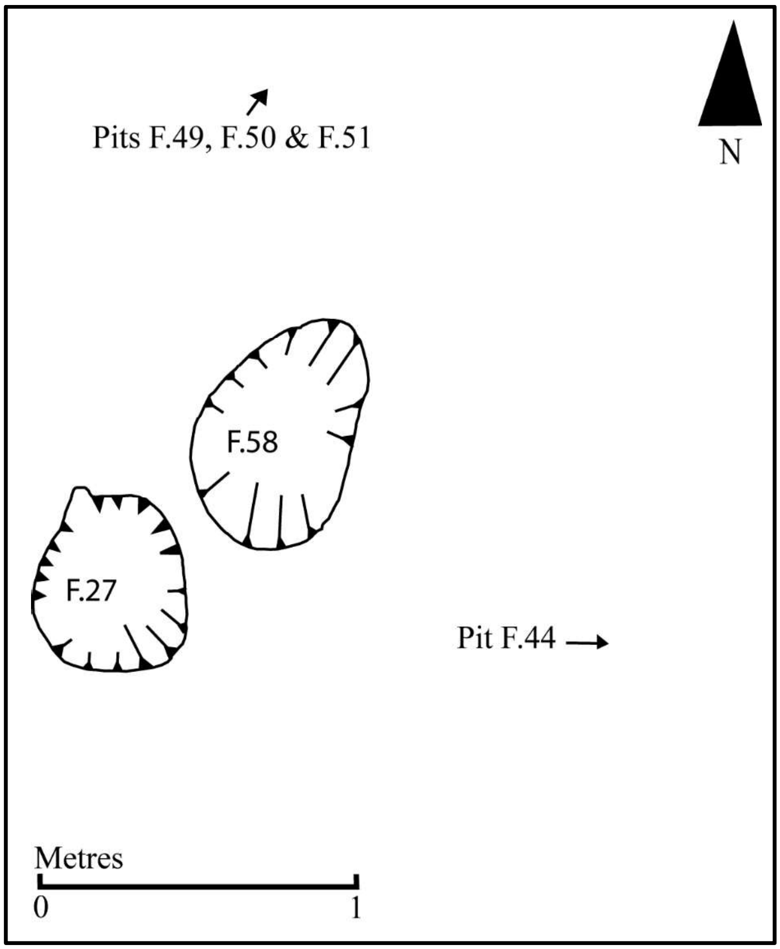

Figure B.42 Neolithic pits F.27 & F.58 from Curraghprevin (site 3)

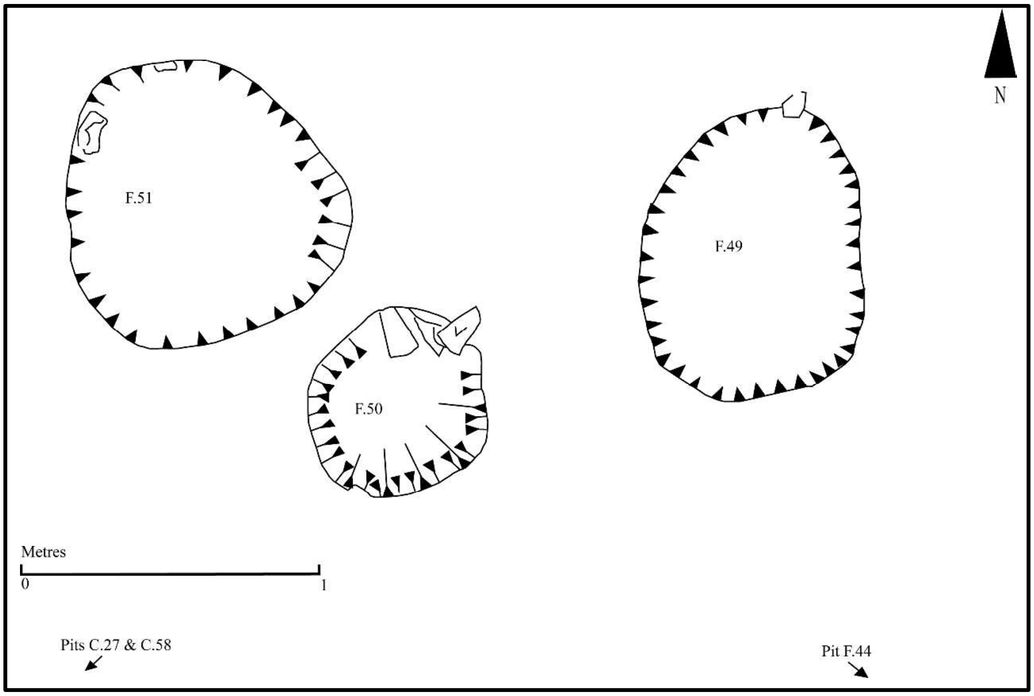

Figure B.43 Neolithic pits F.49, F.50 & F.51 from Curraghprevin (site 3)

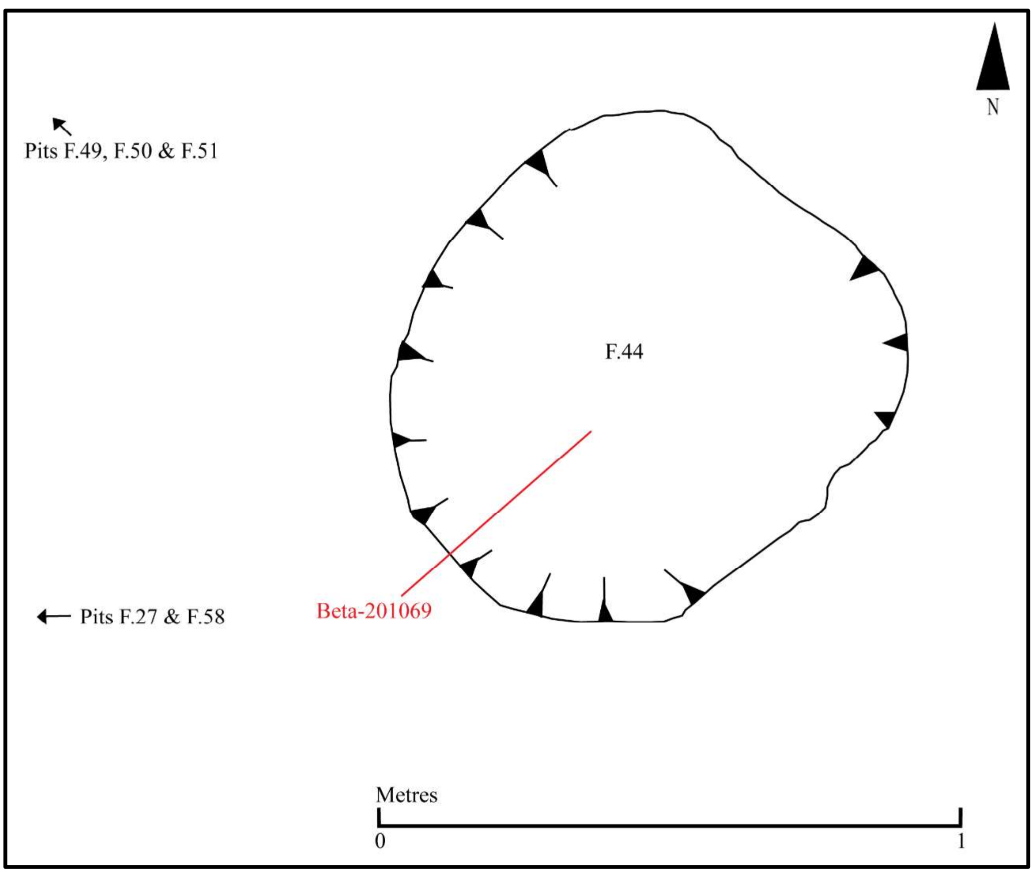

Figure B.44 Neolithic pit F.44 from Curraghprevin (site 3)

(31) Townland: Curraheen (site 1)
Barony: Cork
County: Cork
Site Type: Post-holes/pit, stray finds
SMR:
Excavation Licence Number: 01E1209
ITM: 560860, 569290
National Grid: 160722, 069288
OD: 20m
Reference: (Danaher and Cagney 2004a; Danaher 2013b)
The site was identified in advance of roadworks on the N22 Ballincollig bypass and was fully excavated between January and March 2002. The site showed evidence of multi-period activity with a small number of artefacts dating to the Neolithic retrieved during excavation. A post-hole/pit C.47 contained two sherds of Neolithic pottery. This was truncated by the southern side of Test Trench A as was its neighbouring feature C.45.

Ceramics

Two sherds of Neolithic pottery, a rim and a bodysherd, were recovered from C46 fill of post-hole/pit C47. Both were from the same vessel and it was identified as an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

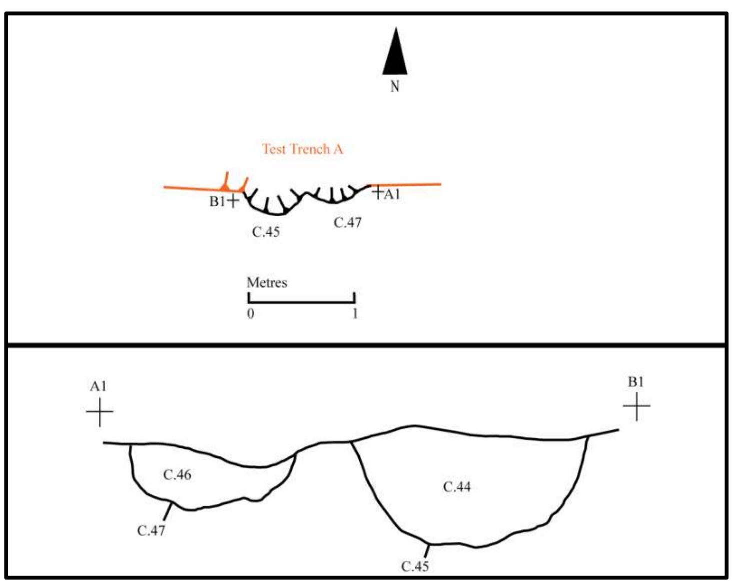

Figure B.45 Neolithic features from Curraheen (site 1) in plan and section

(32) Townland: Danganbeg (site 10-1)

Barony: Kilree

County: Kilkenny

Site Type: Pit

SMR:

Excavation Licence Number: 12E0356

ITM: 651299, 638910

National Grid: 251360, 138863

OD: 72m

Reference: (Hull 2015, 32-34)

The site was excavated in November 2012 in advance of gas pipeline construction. Several Bronze Age features were identified along with a Neolithic pit, C.1123. There were two fills within the pit (C.1177 and C.1170). Charred hazelnut shells were recovered from the primary fill C.1177 and sherds of Neolithic pottery were found in the upper fill (C.1170) of the pit.

Ceramics

Sherds of Neolithic pottery, were recovered from fill C.1170 of pit C.1123 and were identified as from an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

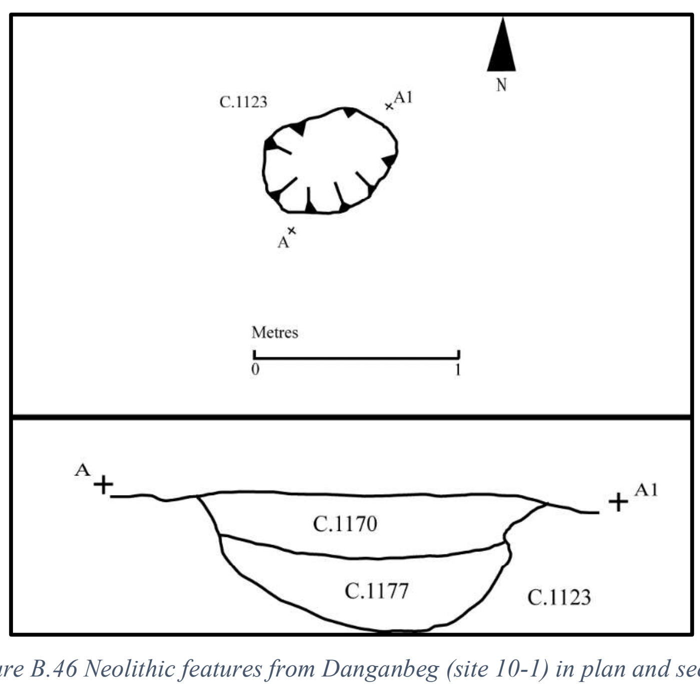

Figure B.46 Neolithic features from Danganbeg (site 10-1) in plan and section

(33) Townland: Danganbeg (site 10-5)

Barony: Kilree

County: Kilkenny

Site Type: Pits

SMR:

Excavation Licence Number: 12E0356

ITM: 651187, 639348

National Grid: 251248, 139301

OD: 89m

Reference: (Hull 2015, 96)

The site was excavated in November 2012 in advance of gas pipeline construction. Two pits (C.1010 and C.1011) were identified during excavation. Pit C.1010, contained two fills, primary fill C.1062 and upper fill, C.1066, which sat in the centre of the pit. A large assemblage of charred plant macrofossils was recovered from the lower fill of pit C.1010. A charred grain of emmer wheat from the primary fill, C.1062, of pit C.1010 was radiocarbon dated to Early Neolithic. Pit C.1011 contained one fill, C.1063 with frequent flecks of charcoal, concentrated at the base. The charcoal from this pit was mixed, mostly hazel with some birch, willow and oak also present. No artefacts were recovered from these features pertaining to function, form or date.

Archaeobotanical remains

All plant remains from Danganbeg (site 10-5) were recovered from fill C.1062 of pit C.1010. The assemblage was dominated by emmer wheat, which accounted for 71% of the identifiable remains. Emmer chaff, in the form of spikelets, were also noted in the assemblage. Grains tentatively identified as emmer/spelt type, indeterminate cereal grains, barley and oat grains were also recovered, albeit in much lower frequencies. A single flax seed was also identified.

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation at Danganbeg (site 10-5) (see Table B.18). Charred emmer wheat from pit C.1010 returned a date range of 3646-3518 cal BC.

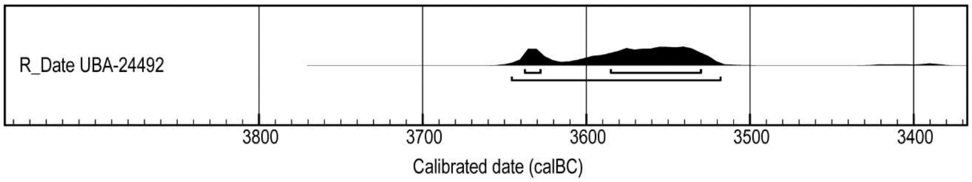

Figure B.47 Calibrated radiocarbon date from Danganbeg (site 10-5)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
UBA-24492	C.1010	Emmer Wheat	4788±33	3646-3518 cal BC	3638-3628 cal BC (9.5%) 3586-3530 cal BC (58.7%)

Table B.18 Calibrated radiocarbon date from Danganbeg (site 10-5)

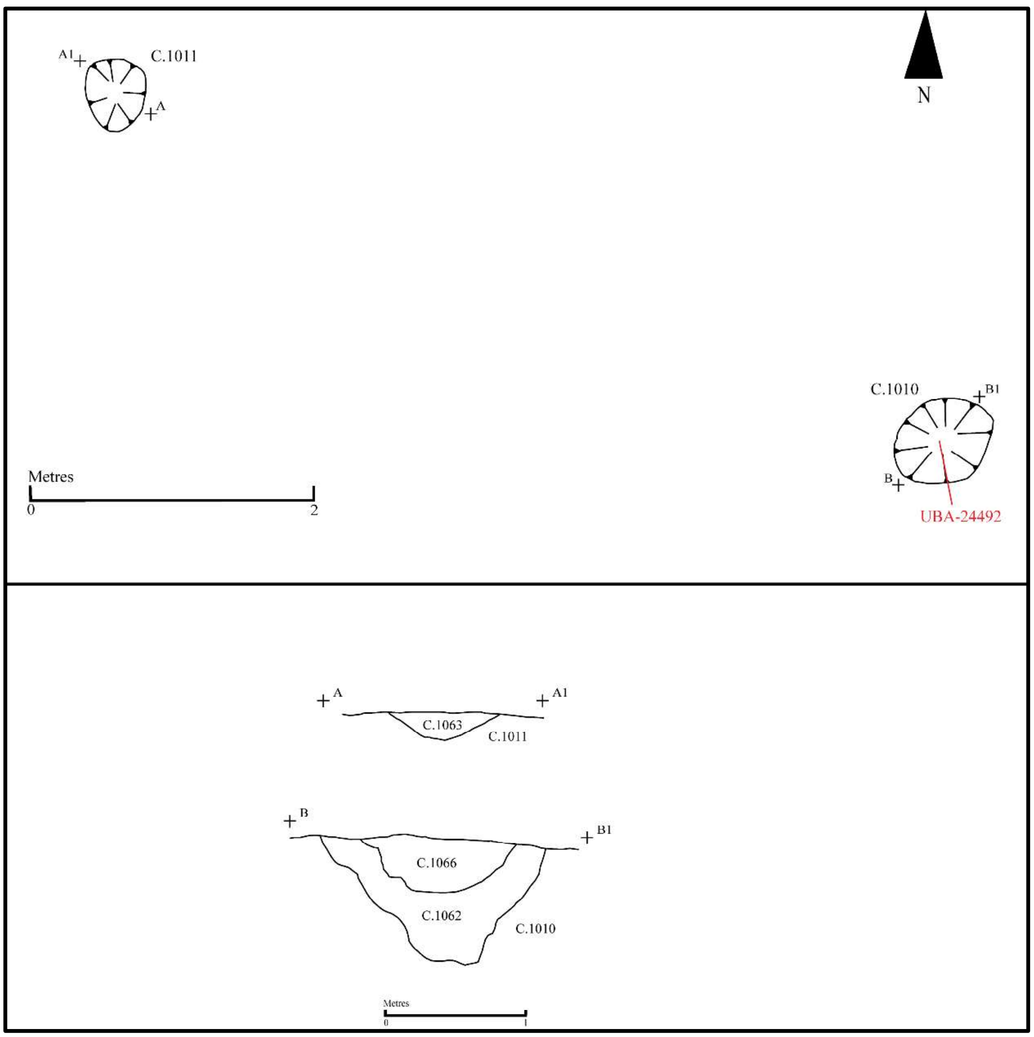

Figure B.48 Neolithic features from Danganbeg (site 10-5)

(34) Townland: Dunhill

Barony: Middlethird

County: Waterford

Site Type: Portal Tomb

SMR: WA025-029----

Excavation Licence Number: N/A

ITM: 650401, 602191

National Grid: 250461, 102135

OD: 100-200m

Reference: (Atkins 1896, 71-72; Borlase 1897, vol 1, 57; Ó Nualláin 1983, 103; Moore 1999, 2)

The site is located in pasture on a fairly steep south east facing slope of the north-south valley of the Annestown stream, which is *c.* 210m to the east. A large roof-stone, *c.*4m by *c.*2.7m and *c.*1.2m max thickness is supported by one orthostat, *c.*1.2m high and a prostrate stone. The site has not been excavated.

(35) Townland: Earlsrath (site AR031)
Barony: Knocktopher
County: Kilkenny
Site Type: Neolithic Rectangular Houses
SMR: KK040-081----, KK040-082----
Excavation Licence Number: E3005
ITM: 656368, 626741
National Grid: 256429, 126691
OD:
Reference: (Mckinstry 2009; 2010a)

The site was identified in advance of roadworks on the N9/N10 Waterford to Kilcullen Road Scheme and was fully excavated between June and September 2006. Two rectangular structures were excavated at Earlsrath (site AR031).

Structure 1

Structure 1 was a rectangular shaped structure and consisted of a large four-sided rectangular foundation trench C.4 within which were a number of post-impressions and post-holes. An internal foundation trench C.10 divided the structure in two and two internal post-holes C.45 and C.113 may suggest that the structure had another internal division, but it is more likely that the posts were there to support the roof. The structure was approximately 11.50m by 7.80m and had a northeast southwest orientation.

South-western foundation trench

Three post-holes were identified in the southwestern foundation trench, post-hole C.100 was located at the north-eastern corner of the foundation trench, post-hole C.105 at the south-eastern, with post-hole C.91 located in between these. Flint debitage was retrieved from fill C.92 of post-hole C.91. The south-western foundation trench contained two fills C.19 which was sealed by C.67. Oak charcoal from fill C.19 of southwestern foundation trench C.4 returned a Neolithic date range

North-western foundation trench

The north-western foundation trench was truncated by a later ditch C.5. The foundation trench in this section contained two fills, C.43 (near corner post C.100) and C76, within which a burnt stone axe was recovered lying directly on the base of the foundation trench. A further large post-hole C.104 was identified in the northern end of the trench.

North-eastern foundation trench

This short section of foundation trench terminated 1.50m from the north-eastern corner of the structure. Two post-holes C.77 and C.111 were located within the trench, one of these C.77 at the terminus. The gap in the outer trench at the northeast corner appeared to be the entrance to the structure. The entrance measured 1.50m across and was located between the corner post-hole C72 and post-hole C.77. Both post-holes were substantial enough to have housed load-bearing uprights.

South-eastern foundation trench

This second long trench was also truncated by the later ditch C.5. The basal fills C.65 and C.66 of the south-eastern foundation trench contained flint debitage and worked rock crystal as well as a rubbing or hammer stone. The northeast corner terminated at the largest post-hole C.72 in the structure, and adjacent to the probable entranceway. A charred hazelnut shell from its basal fill C.73 returned a Neolithic date range. This was overlain by an upper fill C.79 which contained some flint debitage and tiny fragments of Neolithic pottery. A further post-hole C.89was found south of the mid-point of the trench and was aligned with two internal post-holes C.45 and C.113.

Internal foundation trench

Except for the absence of post-holes, the internal foundation trench C.10 was identical to the outer foundation trench C.4. C.10 contained two fills, C.11 and C.103. C.11 contained small pieces of early Neolithic pottery and flint debitage, while a possible polishing stone was also recovered from fill C.103. The trench divided the structure into two rooms, a larger southwestern room measuring 7.50m by 6m (internally) and a smaller north-eastern room or antechamber measuring 2m by 6m and accessed by the probable entrance.

Internal post-holes

Two large post-holes (C.45 and C.113), appear to have been for substantial roof supports, or along with the aligned post-hole C.89 in the south-eastern trench, may also suggest a structural cross wall was formed, parallel to the internal foundation trench C.10. Alder charcoal from fill C.39 of post-hole C.45 returned an Early Neolithic date range.

Structure 2

Structure 2 was located approximately 4m to the northwest of structure 1. It was a rectangular shaped structure with three sides that consisted of shallow foundation trenches C.7 and C.13. There was no evidence of a fourth wall, but a shallow foundation trench might not have survived at this end. The structure was approximately 13.10m by 7m and had a northeast-southwest orientation.

Foundation trenches

The north eastern and south-eastern walls C.7 are represented by two L-shaped foundation trenches, identical in character and containing the same fill (C.9) throughout. A sample of hazelnut fragments from C.9 returned an Early Bronze Age date range and was likely intrusive as a large number of post-medieval finds were also recovered from the top of the fill. The north-western foundation trench C.13 was slightly different in character from the other two. Whilst similar in profile and depth, the sides of the foundation trench were lined with flat stones. These may have originally supported upright planks or posts. Pine charcoal from its fill C.12 was dated to Early Neolithic.

Internal features

Two shallow pits C.119 and C.120 were encountered within the interior of the structure. Finds from the pit C.120 included fragments of Neolithic pottery and flint flakes, including a possible projectile point. An irregular curvilinear gully or trench C.83 (possibly an internal division) was identified in the north-eastern part of the interior of structure 2. The feature measured 3.10m by 0.90m and 0.58m deep. A charcoal sample of hazel from fill C.70 returned an Early Neolithic date range.

Ceramics

Sherds of Neolithic pottery, were recovered from fill C.11 of trench C.10 (structure 1), fill C.40 of pit C.120 and fill C.70 of pit C.83 (both structure 2) and were identified as from an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

Nine pieces of lithic material were recovered from contexts associated with structure 1. Three small pieces of fine flint micro-debitage and an irregular chert chunk were recovered from four individual fills of an external slot trench (C.4). A small burnt flint chunk was retrieved from C.11, a fill of C.10. In addition to this burnt flint chunk, a sub-oval flat pebble which was smoothed and exhibited striations was recovered from C.103, a second fill of C.10. A mid- Late Neolithic flaked and partially polished/ground stone axe was recovered from C.76, a fill of C.104 a post-hole in bedding trench C.4. A second post-hole (C.105) from within slot C.4 produced a round pink quartzite broken pebble hammer-stone and a large irregular crystal of rock crystal. Three pieces of flint were recovered from structure 2, a portion of a possible irregular projectile point a portion of flint simple modified flake and a single small weathered and heavily patinated flint chunk. All were retrieved from fill C.40 of post-hole C.120.

Archaeobotanical remains

Charred hazelnut shell fragments were recorded in fill C.67 of the south-western foundation trench C.4 (structure 1). One charred wheat grain was also present, which appears to be of emmer wheat. One charred possible indeterminate cereal grain fragment was recorded. Charred hazelnut shell fragments were also recorded from fill C.9 of slot trench C.7 (structure 2). A possible emmer wheat spikelet fork was also recorded. A small number of charred indeterminate cereal grains were present, most of which were very poorly preserved.

Radiocarbon dating

Five Early Neolithic radiocarbon dates were obtained from the excavation at Earlsrath (site AR013) (see Table B.19). Three were associated with structure 1, oak charcoal from foundation trench C.4 returned a date range of 3764-3642 cal BC, alder charcoal from post-hole C.45 returned a date range of 3788-3660 cal BC and charred hazelnut shells from of post-hole C.72 returned a date range of 3702-3524 cal BC. Two were associated with structure 2, hazel charcoal from pit C.83 returned a date range of 3766-3644 cal BC and pine charcoal from foundation trench C.13 returned a date range of 4226-3970 cal BC. Additionally, a sample of hazelnut shell fragments from fill C.9 of foundation trench C.7 (structure 2) returned a date of 2617-2467 cal BC (*UBA-14159*, 4005±32BP), this is however likely to be intrusive in the context.

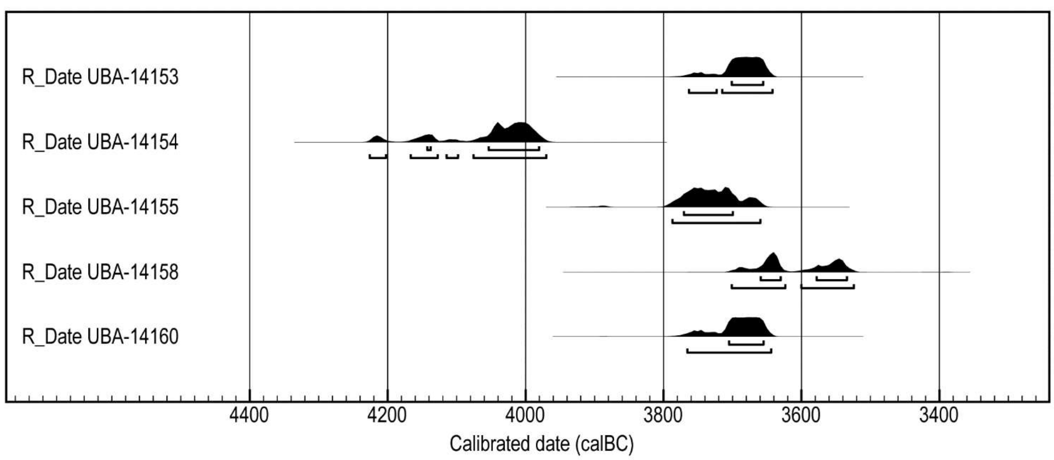

Figure B.49 Calibrated radiocarbon dates from Earlsrath (site AR031)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-14153	C.4 (structure 1)	Oak Charcoal	4912±30	3764-3724 cal BC (10.2%) 3716-3642 cal BC (85.2%)	3702-3656 cal BC (68.2%)
UBA-14154	C.13 (structure 2)	Pine Charcoal	5239±31	4226-4203 cal BC (6.1%) 4167-4128 cal BC (11.7%) 4115-4098 cal BC (2.3%) 4076-3970 cal BC (75.3%)	4143-4138 cal BC (2.2%) 4054-3981 cal BC (66.0%)
UBA-14155	C.45 (structure 1)	Alder Charcoal	4956±29	3788-3660 cal BC	3771-3700 cal BC
UBA-14158	C.72 (structure 1)	Hazelnut Shell	4835±41	3702-3624 cal BC (51.1%) 3600-3524 cal BC (44.3%)	3660-3630 cal BC (34.4%) 3578-3534 cal BC (33.8%)
UBA-14160	C.83 (structure 2)	Hazel Charcoal	4917±31	3766-3644 cal BC (95.4%)	3706-3656 cal BC (68.2%)

Table B.19 Calibrated radiocarbon dates from Earlsrath (site AR031)

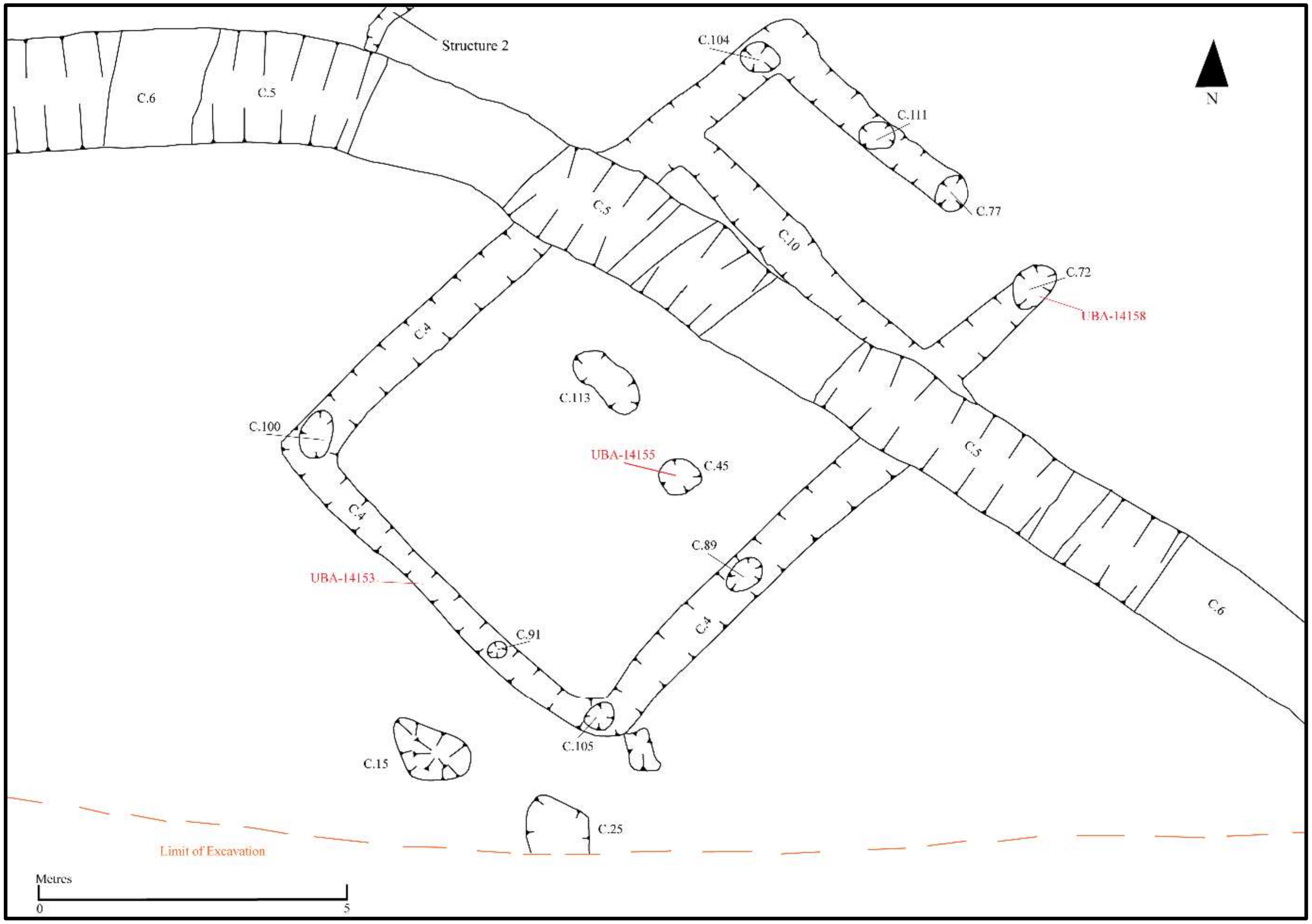

Figure B.50 Structure 1, Earlsrath (site AR031)

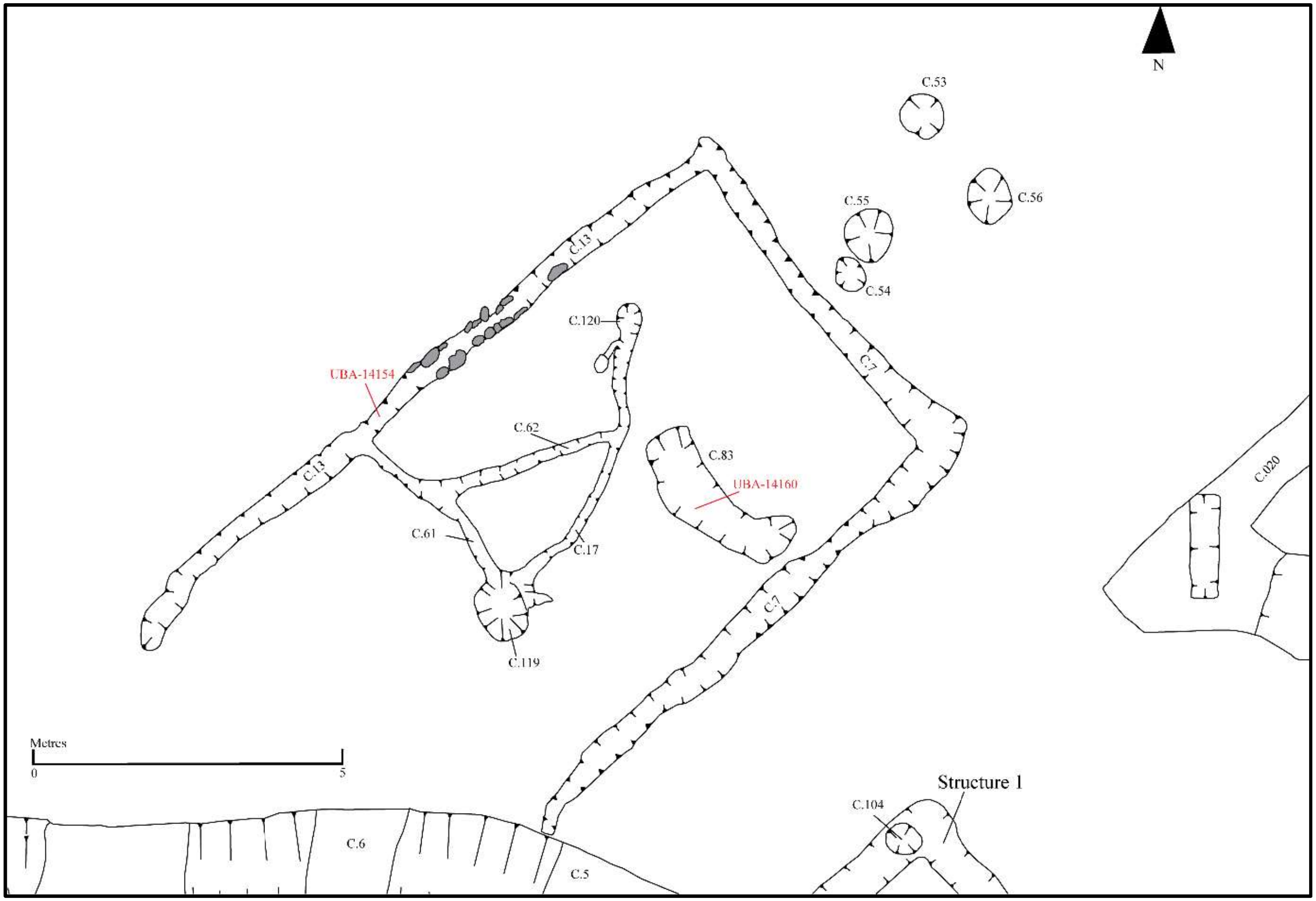

Figure B.51 Structure 2, Earlsrath (site AR031)

(36) Townland: Gaulstown

Barony: Middlethird

County: Waterford

Site Type: Portal Tomb

SMR: WA017-027----

Excavation Licence Number: N/A

ITM: 653945, 606291

National Grid: 254006, 106236

OD: 200-300m

Reference: (Du Noyer 1866, 480; Atkins 1896, 76-77; Borlase 1897, vol. 1, 58-59; Ó Nualláin 1983, 103; O'Carroll 1985, 20, 23; Harbison 1992, 325; Moore 1999, 2)

The site is located in scrub at the bottom of a steep north facing slope, *c.*4km south of the River Suir. Constructed of a local stone and surviving complete facing south-east into the hillside. A rectangular roof-stone *c.*4.2m by *c.*2.55m with a maximum thickness of *c.*1m is resting on two portal-stones, *c.*2.25m high, and a back-stone, with two side-stones and a sill-stone. A cist (WA017-026----) *c.*8m to the north-west may have shared the same cairn as this portal tomb. The site has not been excavated.

(37) Townland: Glencloghlea

Barony: Ida

County: Kilkenny

Site Type: Portal Tomb

SMR: KK037-023----

Excavation Licence Number: N/A

ITM: 668836, 627699

National Grid: 268900, 127649

OD: 100-200m

Reference: (Borlase 1897, 410; Ó Nualláin 1983, 97)

The site is located in sloping pasture on the side of a shallow valley, close to a stream which joins the River Barrow *c.*2.2km to the south-east. A roof-stone measuring *c.*3m by *c.*2m with a maximum thickness of 1.1m rests on a small ruin chamber. A portal-stone, *c.*1.55m high and door-stone *c.*1.3m high also remain of the chamber. The site has not been excavated.

(38) Townland: Gortnahown (site 2)

Barony: Condons and Clangibbon

County: Cork

Site Type: Pit group and associated features

SMR:

Excavation Licence Number: E2426

ITM: 580805, 609645

National Grid: 180850, 109591

OD: 120m

Reference: (Kiely and O'Donoghue 2010)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between February and May 2007. Early Neolithic activity was uncovered in Area 3 of the site. Nine of the pits (C.1055, C.1107, C.1111, C.1137, C.1112, C.1123, C.1117, C.1047 and C.1104) and seven post-holes and seven stake-holes were identified in the in the north-eastern corner of Area 3. Twelve sherds of pottery were recovered from the upper fill of pit C.1055 and four sherds were recovered from the fill of pit C.1123. Six stake-holes were located to the north and south of the pit. Four of the stakes (C.1130, C.1131, C.1133 and C.1134) could have formed a small windbreak or structure over the pit such as a grill or spit. Seven pits (C.1104, C.1107, C.1047, C.1117, C.1111, C.1112 and C.1137) and a linear C.1038 formed a group to the north and south of C.1123. Two post-holes (C.1108 and C.1109) cut the base of pit C.1104. Sherds of pottery were recovered from four pits C.1055, C.1107, C.1112, C.1123 and linear feature C.1038. No Neolithic radiocarbon dates were obtained from excavations at Gortnahown (site 2).

Ceramics

A small assemblage of 26 sherds representing four vessels was found in Area 3 of the site. Sherds came from an occupation layer (C.1097), pits C.1054, C.1055, C.1102, C.1107 and C.1121, linear feature C.1039 and a surface find and appears to represent domestic activity. The four vessels were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. A sherd of Early Neolithic Carinated pottery was also found in upper fill C.663 of pit C.673 in Area 2, however, this was found in the same context as Late Neolithic/Early Bronze Age material and may have been residual or redeposited.

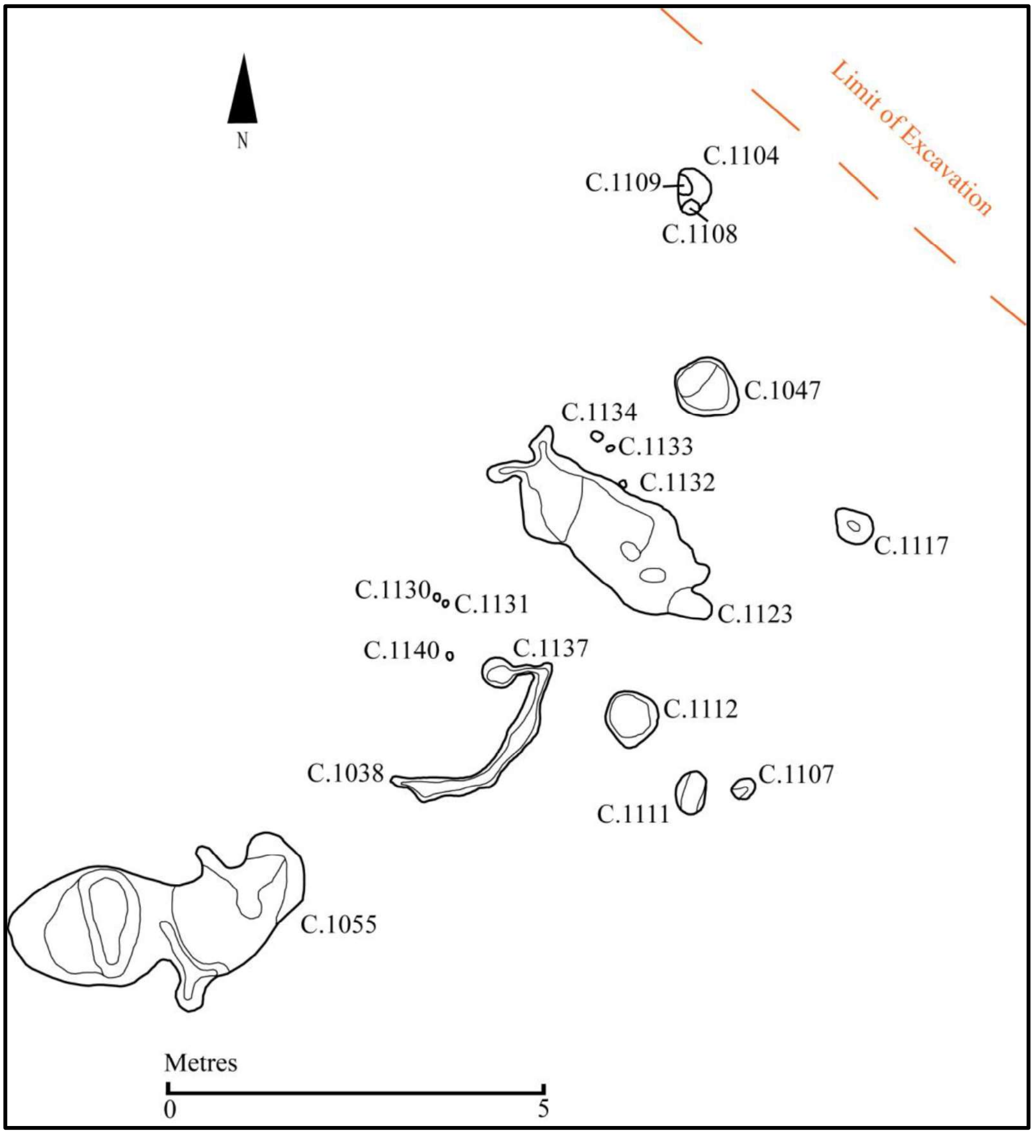

Figure B.52 Neolithic features from Area 3, Gortnahown (site 2)

(39) Townland: Gortonora

Barony: Corkaguiny

County: Kerry

Site Type: Pit and post-hole

SMR:

Excavation Licence Number: 06E1111

ITM: 445274, 601556

National Grid: 45289, 101499

OD:

Reference: (Dunne and Buckley 2006; Dunne 2017, 11)

The site was identified during archaeological monitoring at a proposed development site (PDS) at Gortonora, Dingle. Two discrete archaeological features, a post-hole and a shallow pit, were revealed on the north-eastern side of the PDS at a distance apart of 1.5m. The post-hole was the southernmost of the two features. Lithic finds from the post-hole included a greenstone flake and a piece of white flint debitage. A small ceramic assemblage of sixteen fragments of Early Neolithic round-bottomed shouldered ware, the second feature comprised a shallow pit, filled with loose charcoal-enriched black silt (C3) with frequent charcoal chunks and occasional small sub-angular and angular stones. The cut was regular in shape with very gentle smooth sides and base. Given the shallow nature of the cut, it is possible that the material C3 occupied a natural hollow rather than a deliberate cut. Subsequent cleaning by hand in the vicinity of these features revealed no further archaeological deposits, stratigraphy or artefacts. Post-excavation analysis is ongoing, with radiocarbon dates returned a, (2-sigma, *95.4% probability*), date of 3697-3533 cal BC.

(40) Townland: Gortore (site 1)
Barony: Fermoy
County: Cork
Site Type: Neolithic Rectangular House
SMR: CO027-198----
Excavation Licence Number: E2119
ITM: 581769, 601717
National Grid: 181815, 101661
OD: 30m
Reference: (O'Donoghue 2006; O'Donoghue and Johnston 2013)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated in April 2007. Excavations revealed the remains of Early Neolithic rectangular house. The internal dimensions of the house were 6.3m in length by 5.1m in width, occupying an area of *c*.33m^2.

The eastern wall

The eastern wall of the structure was represented by a foundation trench C.157. Twenty-six sherds of prehistoric pottery were found within fills C.152 and C.158 of C.157. Charcoal from fill C.158 returned an Early Neolithic date range. There were two post-holes within the trench, a circular post C.112 on the northern end and a rectangular post C.162 on the southern end.

The northern wall

The north-western area of the structure was heavily truncated but sufficient evidence survives to establish the existence of a foundation trench along the north line of the structure C.133. The north-eastern trench C.177 is truncated to a lesser extent. An external shallow pit C.132 was located immediately north of the northern wall line.

The western wall

The western wall was defined by a trench C.169 and two irregular cuts C.153 and C.154. These irregular features from the north-western portion of the wall appear to have been heavily truncated. The trench C.169 contained two post-holes C.174 & C.128. A flint flake was recovered from the fill of post-hole C128. A fragment of a hazel nut shell was found at the northern end of C.169. The corner of the foundation trench was connected to the southern wall by post-hole C.114.

The southern wall

The southwestern corner was marked by two post-holes C.109 and C.114. The south-eastern part of the wall comprised a trench C.151. Two post-holes (C.171 and C.113) were located immediately south of the southern wall line. The position and size of post-hole C.113 may indicate an off-centre entrance to the house.

Internal Features

Within the house, one internal post-hole was interpreted as an internal roof support but there were no definite indications of internal sub-divisions and no hearth. A thin layer of re-deposited clay C.138 was recorded within the structure, located to the north of the possible entrance and extending into the centre of the building. This was a compacted deposit and it probably represented a floor surface. Fragments of charcoal, a hazelnut shell and a flint flake were recovered from this layer. The presence of several external post-holes immediately outside the house walls suggests that the roof extended beyond the walls and was supported by external uprights (C.113, C.171 & C.132). It was not possible to align the only internal post-hole at Gortore with any of the external post-holes to suggest the direction of the roof ridge pole.

Ceramics

Sherds of pottery were recovered from fills C.152 and C.158 of foundation trench C.157, fills C.173 and C.179 of foundation trench C.151 and during topsoil stripping (C.101). The poorly preserved sherds represented at least two vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

Lithics

The lithic assemblage from Gortore (site 1) consists of 47 pieces, 40 of which are made of flint, one of chert, two of limestone and four of unknown types of rock. Twelve split pebble fragments, four cores, thirteen flakes, a blade fragment and a fragment of a polished stone axe were recovered. The type of retouched artefacts does not allow for a precise dating of the assemblage; however, the fragment of a polished stone axe suggests a dating of the assemblage to the Neolithic period.

Archaeobotanical remains

Eight samples were taken from the foundation trenches of an Early Neolithic house: from fill C.106 of post-hole C.128, C.107 of post-hole C.114, fills C.112 and C.152 of foundation trench C.157, C.115 of post-hole C.153, fills C.121 and C.125 of post-hole/pit C.154, fill C.164 of foundation trench C.133. The plant remains included hazelnut shell fragments, emmer wheat grains, indeterminate wheat grains, cereals that could not be classified, weed seeds, apple/pear pips and the charred endocarp (core and flesh) of an apple. The plant remains assemblage contained the typical range of Early Neolithic cereals, with emmer wheat being the main identified type.

Radiocarbon dating

A single Early Neolithic radiocarbon date was obtained from the excavation at Gortore (site 1) (see Table B.20). Charcoal from foundation trench C.157 returned a date range of 3928-3655 cal BC.

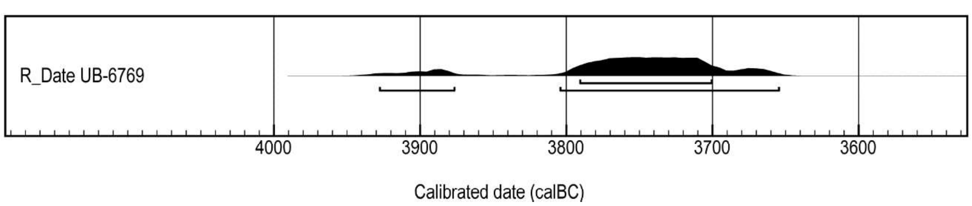

Figure B.53 Calibrated radiocarbon date from Gortore (site 1)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2б) 95.4% Probability	Calibrated Age (1б) 68.2% Probability
UB-6769	C.157	Charcoal	4972±39	3928-3877 cal BC (9.4%) 3804-3655 cal BC (86.0%)	3791-3701 cal BC

Table B.20 Calibrated radiocarbon date from Gortore (site 1)

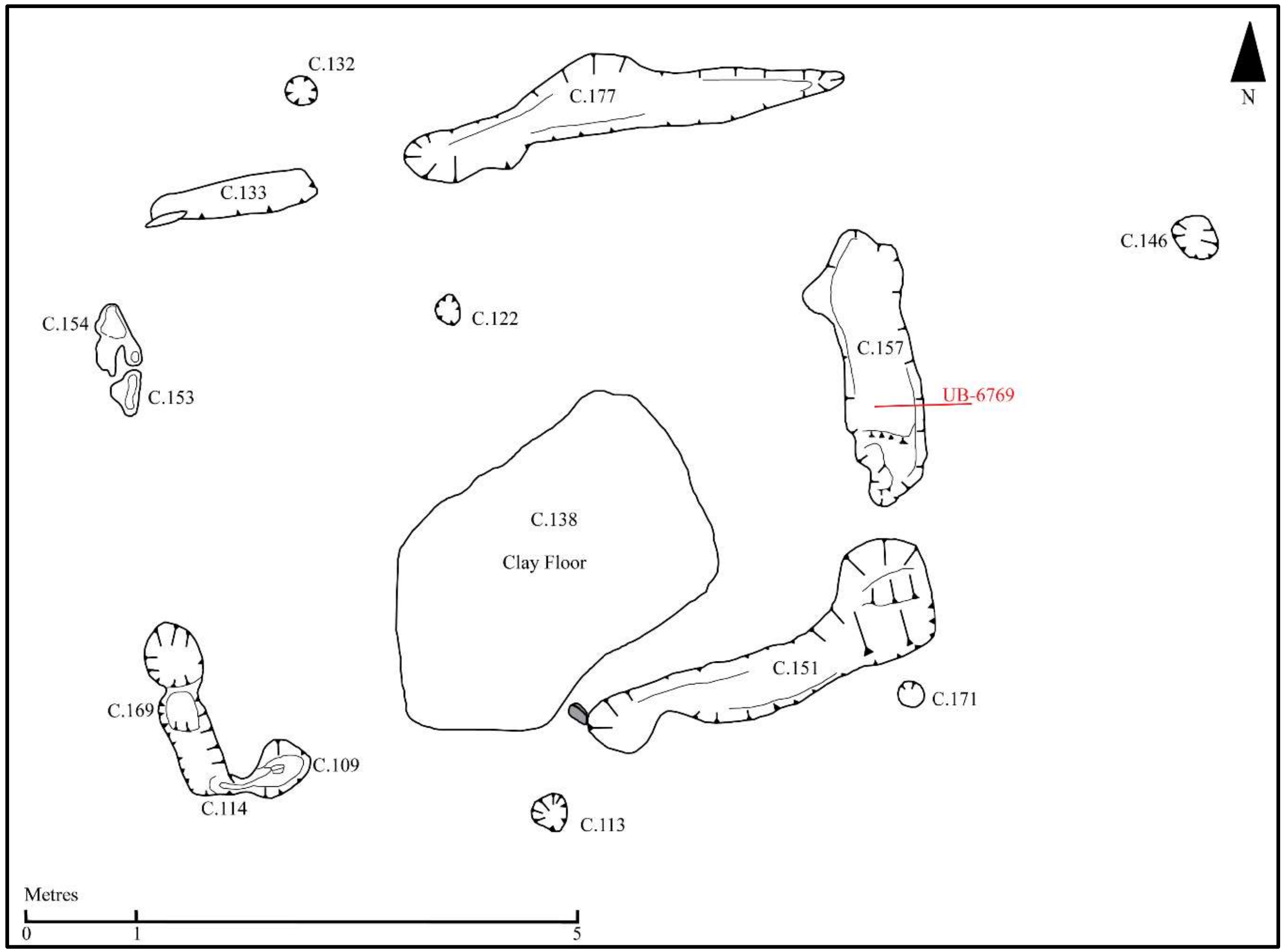

Figure B.54 Neolithic Rectangular House, Gortore (site 1)

(41) Townland: Gortore (site 1b)

Barony: Fermoy

County: Cork

Site Type: Neolithic Rectangular House and associated features

SMR:

Excavation Licence Number: E2410

ITM: 581711, 601655

National Grid: 181757, 101500

OD:

Reference: (O'Donoghue 2011)

The site was identified in advance of roadworks on the N8 Fermoy to Mitchelstown bypass and was fully excavated between September 2007 and February 2008. Excavations revealed Late Mesolithic, Early and Middle Neolithic activity in Areas 1-3 of the site.

Area 1

Excavations in Area 1 revealed the truncated remains of an Early Neolithic rectangular house and associated pit features.

Structure 1

The truncated remains of structure 1 were recorded in Area 1. Two contiguously set slot trenches C.56 and C.103 represented the northern wall of the heavily truncated structure. The return in C.103 marked the northeast corner of the building. A Chalcolithic date (*UB–13224*, 3962±26) was returned from the fill of slot trench C.103. A flint scraper was recovered from the slot trench C.56. The slot trench C.211 was located 1.8m south and parallel to C.56. Eight post-holes (C.265, C.267, C.269, C.271, C.340, C.399, C.422, and C.473) outlined the structure. Four of the post-holes (C.271, C.340, C.269, and C.267) were located 0.8m from and roughly parallel to slot trenches C.56 and C.103 and formed a line 4.2m in length, flanking the slot trenches forming part of the structure. Another four post-holes (C.399, 473, 422 and C.265) were set at a right angle to the south of these and may have acted as roof supports. A Chalcolithic date (*UB-13225*, 3896±25) was returned from the fill of post-hole C.473. Four stake-holes (C.63, C.325, C.357 and C.420) were associated with the area of the structure. Three of them C.357, C.420 and C.63 were aligned east-west 3.5m to the south of slot trenches C.56 and C.103. An Iron date (*UB-13233*, 1873±21) was returned from the fill of stake-hole C.420. A group of ten small pits (C.52, C.57, C.115, C.282, C.327, C.346, C.408, C.422, C.454 and C.456) were located close to the structure. Four small pits (C.282, C.327 and C.346) were located within the structure. A sherd of an Early Neolithic pottery was recovered from C.327. An additional four pits (C.52, C.115, C.422 and C.454) were located on what appears to be the periphery of the structure.

Pits located to south-east of Structure 1

A group of 13 pits (C.6, C.15, C.24, C.31, C.33, C.34, C.37, C.43, C.51, C.95, C.136, C.144 and C.160) were located *c.* 23m to the south-east of structure 1. Three sherds of prehistoric pottery were recovered from pit C.15 and 18 sherds of prehistoric pottery was recovered from pit C.33. The upper fill C.83 of pit C.136 contained 19 sherds of pottery and a split flint pebble. The middle fill C.100 contained three sherds of pottery and the basal fill C.135 also contained four fragments of prehistoric pottery.

Area 2

Area 2 was located 120m to the north of Area 1. A group of nine large pits (C.260, C.337, C.479, C.482, C.548, C.607, C.889, C.1000 and C.1008) were excavated in Area 2. Seven Early Neolithic lithics including flint flakes and debitage were recovered from two of the fills C.151 and C.390 of pit C.260. Over 20 fragments of flint, chert and sandstone lithic finds were recovered from three of the fills C.121, C.264 and C.341 of pit C.479. The majority of the flint was assigned to the Neolithic period, but two fragments were assigned to the Later Mesolithic Period. A Late Mesolithic date (*UB-12983*, 7509±29) was returned from the pit. Hazelnut shell fragments were found in abundance in samples from the large pit C.479. Over 30 fragments of lithic finds, including flint debitage, flakes, a blade, a core and a rubbing stone, were recovered from four of the fills C.519, C.593, C.594 and C.658 of pit C.548. Some of the flint was assigned to the Early Neolithic period but two fragments were assigned to the Later Mesolithic Period. A Late Mesolithic date (*UB-13223*, 5807±29) was returned from the pit. Six pieces of flint debitage were recovered from one of the fill C.542 of pit C.607. A single lithic find was recovered from one of the fill C.894 of pit C.889. Over 30 lithic finds, including some of the blue flint, flint debitage, flakes, blades, a core and a scraper, were recovered from four of the fills C.1039, C.1040, C.1091 and C.1108 of pit C.1000. The lithics were assigned to the Neolithic period. Eight lithic finds assigned to the Neolithic period, a sherd of Early Neolithic pottery and a sherd of Middle Neolithic pottery were recovered from two of the fills C.922 and C.948 of pit C.1088. Six large irregular pits were located on the northern edge of the area of excavation in Area 2 and Area 3.

Three were located in Area 2 (C.527, C.622 and C.1122) and three in Area 3 (C.1154, C.1228 and C.1253). A total of ten Neolithic lithics, including flint debitage, flakes, blades, a core and a sandstone rubbing stone, were recovered from two of the fills C.130 and C.528 of pit C.527. An abundance of hazelnut shells and a small quantity of other plant items, associated with food waste, were recovered from samples from the pit. A Late Mesolithic date (*UB-10500*, 7219±29) was returned from hazelnut shell from pit C.527. Lithic artefacts dated to the Early Neolithic were recovered from the fill C.531 of pit C.622. A Late Mesolithic date (*UB–13222*, 6981±31) was returned from charcoal from the pit. Hazelnuts were also recovered from this pit. A total of 19 small pits (C.133, C.141, C.143, C.221, C.228, C.244, C.276, C.287, C.296, C.305, C.345, C.347, C.350, C.424, C.592, C.606, C.767, C.897 and C.914) were recorded in Area 2. Early Neolithic pottery was also recovered from pit C.592. Two pieces of flint debitage and a sherd of Early Neolithic pottery was recovered from occupation material in a hollow to the north of pit C.767.

Area 3

Area 3 is located adjacent to Area 2. A group of pits, post-holes, stake-holes, hearths and a group of occupation layers that had accumulated in hollows were recorded in Area 3. There were at least 25 small pits evenly dispersed throughout this area. A sherd of Middle Neolithic pottery was recovered from C.770. Three retouched artefacts and flint debitage, assigned to the Neolithic, were recovered from the fill of pit C.217 and fired clay fragments were recovered from the pit C.465. Sherds of Early and Middle Neolithic pottery were also recovered from the fills of the pit C.1063. C.1231 produced a fragment of a leaf-shaped arrowhead and eleven pieces of debitage. C.1256 produced a fragment of a leaf-shaped arrowhead and three pieces of debitage. Two fragments of a Middle

Neolithic pottery were recovered from pit C.1147. A Middle Neolithic date (*UB-13400*, 4576±35) was returned from the pit C.1127. A sherd of Middle Neolithic pottery, flint debitage, rubbing stones and a schist polished axe, were recovered from pit C.930. A sherd of Middle Neolithic pottery and a rubbing/hammer stone were recovered from pit C.806. Pits C.1262, and C.1326 produced sherds of Early Neolithic pottery and C.1330 produced sherds from a Middle Neolithic pottery.

Several lithic artefacts and Early and Middle Neolithic pottery were recovered from the pit C.1063. A total of at least 27 post-holes (C.165, C.210, C.214, C.250, C.280, C.281, C.335, C.434, C.536, C.543, C.546, C.555, C.589, C.590, C.670, C.681, C.787, C.797, C.803, C.816, C.848, C.849, C.850, C.866, C.867, C.877, C.1335 and C.1362) were identified in this area. Although there was no discernible pattern, these post-holes may represent elements of one or more structures. Fragments of both Early and Middle Neolithic pottery were recovered from the immediate environs of the post-holes suggesting that all of the post-holes may not be contemporary. A rubbing stone, a rubbing /hammer stone, sherd of a Middle Neolithic pottery, and three sherds of Early Neolithic pottery were recovered from these layers. Occupation layer C.817 produced sherds of Middle Neolithic pottery, 12 pieces of debitage, a hollow scraper and polished stone axe. Six pieces of flint and sherds of Early and Middle Neolithic pottery were recovered from the layer C.1255.

Ceramics

Area 1 produced a small assemblage of 53 sherds of Early Neolithic pottery represented at least five vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland. Five fragments of Middle Neolithic pottery (Vessel 6) were found in a pit in Area 1 and were identified as and would have formed a globular-shaped bowl similar in form to a vessel from Annaghmare, Co. Armagh (Herity 1982). Area 2 produced a small assemblage of four sherds Early Neolithic pottery representing up to three separate domestic vessels (Nos 7–9). Three fragments of a Middle Neolithic Globular bowl (Vessel 10) were found in pit C.948 in Area 2. Area 3 produced 86 sherds Early Neolithic pottery representing up to seven separate domestic vessels (Nos 11–17). Sixty-two sherds of Middle Neolithic Globular bowls (Vessels 18–23) were found in pits, post-holes, occupation layers and a possible slot trench, as well as some surface finds in Area 3 (C. 218, 314, 754, 763, 817, 927, 1041, 1058, 1087, 1123, 1146, 1255, 1261, 1283).

Lithics

Six-hundred-and-seventy-three lithic finds from the archaeological excavations of a predominantly Neolithic habitation site at Gortore (site 1b). These included 41 cores, 52 blades, 224 flakes, 201 pieces of debitage, 19 scrapers, 2 leaf shaped arrowheads, 2 awls and 4 invasively retouched forms. The majority of artefacts are associated with the Neolithic house and its environs and include the leaf-shaped arrowheads, possibly the invasively retouched forms, some of the miscellaneous retouched artefacts as well as the majority of the single platform cores, blades and flakes.

Archaeobotanical remains

Only three samples with plant remains from cut features C.399, C.420 and C.473 were associated with the Early Neolithic house at Gortore (site 1b). The remains were very poorly preserved and included a small amount of hazelnut shell fragments, some indeterminate cereal grains and possible tuber fragments. Post-hole C.1233 from Area 3 contained more than ten cereal grains. Most of the grains were indeterminate cereal grains but some of the remains were identified as barley and wheat. The finds from this area of the site included some Early and Middle Neolithic vessels and it is possible that theses also date to the Neolithic.

Radiocarbon dating

No Early Neolithic radiocarbon dates were returned from samples recovered during excavation. One Middle Neolithic, two Chalcolithic and one Iron Age date were returned for the rectangular structure, these are likely intrusive due to the truncated nature of the site. Various Late Mesolithic dates were also returned from features throughout the site.

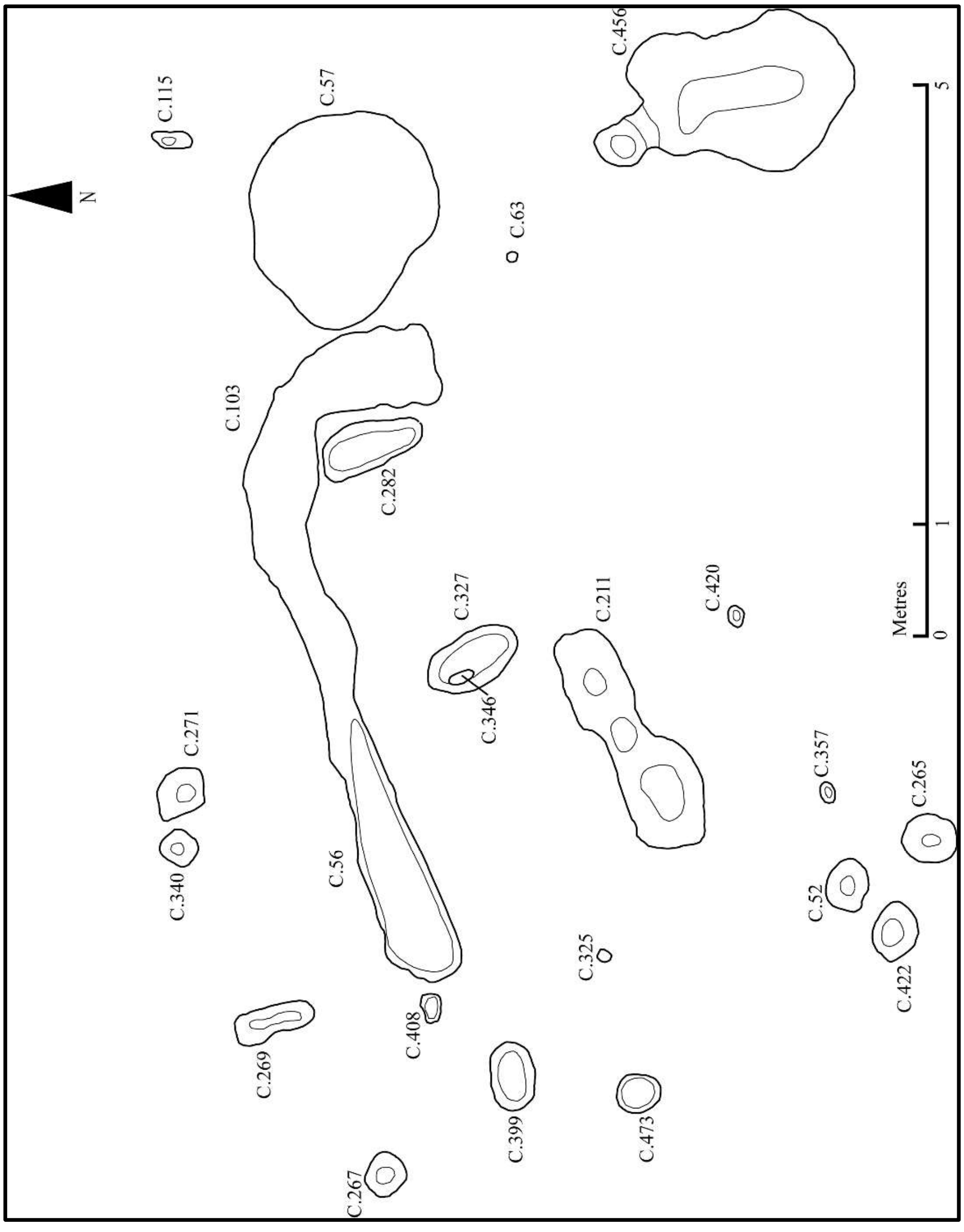

Figure B.55 Early Neolithic rectangular house from Gortore (site 1b)

(42) Townland: Graigueshoneen

Barony: Decies without Drum

County: Waterford

Site Type: Pits and associated features

SMR:

Excavation Licence Number: 98E0575

ITM: 638079, 604762

National Grid: 238136, 104707

OD:

Reference: (Tierney 2005; Tierney and Frazer 2008)

The site was identified in advance of road works on the N25 Kilmacthomas realignment. A group of features were excavated in Grid 110 in Field 3. A possible hearth C.7778 was located in the southwestern portion of the grid. Three stake-holes C.7767, C.7769 and C.7790 and a small pit C.7763 were associated with the hearth. A second pit C.7798 was located 1m to the east of the hearth. A group of thirteen stake-holes and pits C.7775, C.7777, C.7788, C.7791, C.7792, C.7793, C.7801, C.7802, C.7803, C.7835, C.7836, C.7839, C.7840 were located in the northern section of the grid. The small pit C.7802 contained sherds of Early Neolithic pottery. The other six pits C.7839, C.7840, C.7791, C.7793, C.7803 and C.7836 were clustered in an east-west alignment that measured *c.*1m north-south by 4m east-west. Three stake-holes, C.7801, C.7788, & C.7777, aligned north-south, were located to the immediate east of the pit C.7802. The hearth, pits and stake-holes represent the truncated remains of Early Neolithic settlement activity. No evidence of a Neolithic structure enclosing the above features was recorded.

Ceramics

The fill of pit C.7802 produced a small assemblage of 3 sherds of pottery represented at least one vessel, identified as an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8) in Ireland.

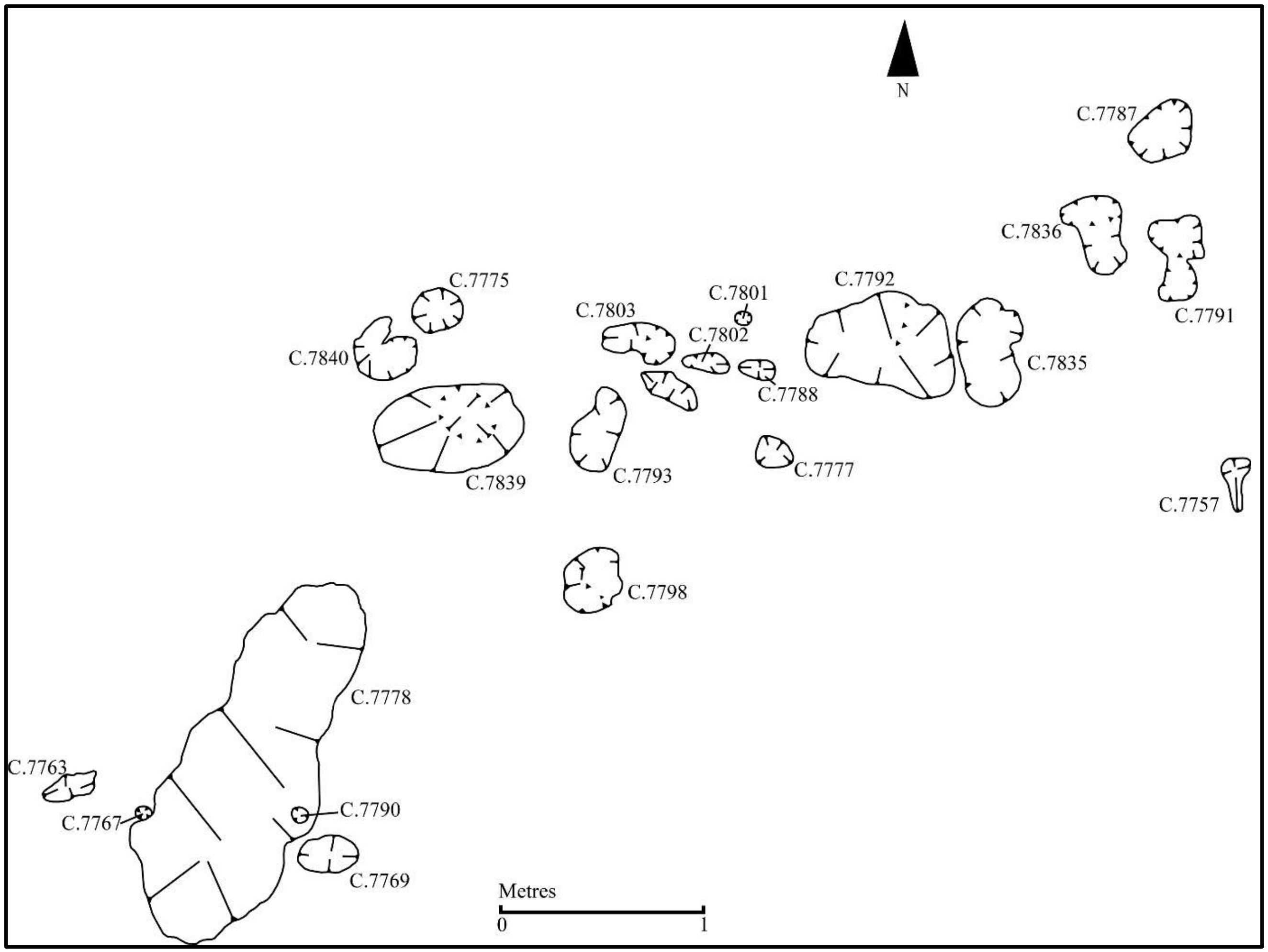

Figure B.56 Neolithic features from Graigueshoneen

(43) Townland: Granny (site 27)
Barony: Iverk
County: Kilkenny
Site Type: Neolithic Rectangular House
SMR:
Excavation Licence Number: 04E0548
ITM: 657779, 615476
National Grid: 257841, 115423
OD:
Reference: (Hughes 2006)

The site was identified in advance of roadworks on the N25 Waterford bypass and was fully excavated between April and July 2004. Excavation revealed two Neolithic structures and associated features.

Structure 1

Foundation trench and structural post-holes

A fairly regular square-shaped foundation trench C.27123 associated with numerous post-holes was identified in the south of the site and is referred to as structure 1. Oak charcoal from this trench returned a Neolithic date range. Some excavated features, post-hole C.27231, stake-hole C.27292 and post-hole C.27387 appear to pre-date the foundation trench, although there was no obvious pattern to their location with regard to the construction of the house. Post-hole C.27387 produced 3 sherds of pottery. The southern side of the foundation trench contained within two post-holes, C.27422 in the southeastern corner and C.27231 in the southwestern corner. The entrance on the southern side of the building was defined on the east by a shallow terminus, and by post-hole C.27420 on the western side. The eastern section of the foundation trench was marked by post-holes C.27422 in the southeast corner and C.27253 in the north-eastern corner. Two further post-holes C.27290 and C27258 were located along the eastern section of the foundation trench. The northernmost portion of the foundation trench was marked by post-holes C.27253 in the northeast corner and C.27207 in the northwest corner. Two unusual kinks were noted along its course, the first was seen externally to the west of central post-hole 27387 and the second was internal and associated with the cut of the same post-hole. The fill of the foundation trench C27124 was partially sealed by an internal spread of cobbles C.27245. The majority of the pottery recovered from the site was from fill C.27124 on the northern side of the building. The western side of the structure was marked by post-hole C.27207 in the northwest corner with no identifiable post-hole in the southwest corner and two post-holes C.27209 and C.27464 along its course. A possible entrance to the structure was noted between post-holes C.27209 and C.27464, where the foundation trench was most narrow and shallow. At the southwest corner, a shallow pit 27400 cut the foundation trench. The botanical remains recovered from the main fill, C.27123, of the foundation trench included carbonised hazelnut shell, and one sample of badly abraded charred cereal grains of indeterminate species.

Internal features

Two discrete spreads of cobbles C.27340 and C.27245 were identified within the structure. The two spreads appeared on either side of a possible entrance in the eastern section of the foundation trench. The cobbled spreads were interpreted as attempts to level the ground surface around natural depressions that may have formed during the life of the building because of slumping over natural solution holes in the underlying limestone bedrock. The finds from cobbled spread C.27340 included an anvil stone and a small polished flint pebble. Carbonized hazelnut shell fragments were also recovered from this deposit. Cobbled spread C.27245 consisted of compacted heat-affected stones concentrated in the northern part of the structure and contained a sherd of Neolithic pottery. Fragments of carbonized hazelnut shell and charred cereal grains of indeterminate species were recovered from this feature. Elm charcoal from C.27245 returned a Neolithic date range. Other internal deposits included C.27220, restricted to the southwestern corner of the structure, carbonized hazelnut shell fragments and charred cereal grains of indeterminate species were also recovered from this deposit. Floor deposit C27574 sealed several underlying pits (C.27486, C.27549, C.27569, C.27581 and C.27603) and stake-holes (C.27368 and C.27370). It was probably cut by several post-holes or stake-holes (C.27127, C.27381, C.27567 and C.27344). Stake-hole C.27344 contained charred cereal grains of indeterminate species in its fill and pit 27569 contained carbonized hazelnut shell fragments.

External features

To the south of structure four post-holes (C.27150, C.27152, C.27438 & C.27631) in a rectangular arrangement were interpreted as part of a possible porch outside an entrance to the structure. To the north-eastern corner feature forming part of the possible porch was a sub-circular pit C.27152. Its single fill (C.27153) contained carbonized hazelnut shells and sherds of pottery

Neolithic Structure 2

Foundation trenches, structural post-holes and pits

The main structural feature associated with structure 2 was an 'L'-shaped foundation trench C.27374 on the west and south side of the building. Overall the foundation trench was very irregular in profile and plan. Seven pottery sherds were recovered from the fill of the western part of the foundation trench, but none were recovered from the southern side. A clearly defined post-hole C.27320 was located less than 0.1m from the eastern terminus of foundation trench. The absence of features between this post-hole and post-hole (27492), 1.6m to the east, suggested a possible entrance at this location. The suggestion of a foundation trench in the form of 27306, in conjunction with post-hole 27314 formed the northern side of the structure. At the southeast corner of the structure, C27492 appeared as a single shallow, irregular pit-like feature, which cut through earlier pit C.27494. A number of packing stones at the northern side of fill C.27493 of C.27492 suggested it was a structural function, although it was quite shallow and irregular. Carbonized hazelnut fragments were recovered from C.27492. The final suggestion of a foundation trench was provided in the form of conjoined features C.27518, C.27520 and C.27495, which were orientated perpendicular to the eastern side of the structure 2. The remainder of structure 02 comprised a number of well-defined post-holes. Located east of C.27383 was post-hole C.27318. Sherds of pottery were recovered from this feature. Post-hole C.27506 was located to the east of C.27318, at the southeast corner of structure 2. The eastern side of the structure was less clearly defined than the western or southern. It comprised post-hole C.27506, possible foundation trench C.27492/27494 and feature C.27522. Feature C.27522, C.27518, and post-hole C.27314 formed the northeast corner of structure 2. Oak charcoal from post-hole C.27314 returned a Neolithic radiocarbon date range. Unlike structure 1 no floor deposits were identified within structure 2.

Internal features

Pit C.27322 was located close to the southwestern corner of the structure and contained three distinct deposits. The basal fill C.27325 provided evidence for burning in-situ. This inferred that the original function of this feature may have been as a roasting pit, and the presence of charred hazelnut shell and charred cereal grains of indeterminate species in both deposits strengthened this theory. Two possible phases of use for this pit were suggested by the presence of a layer of re-deposited subsoil C.27324, which separated the upper and lower deposits within C.27322. Hazelnut shells from pit C.27325 returned a Neolithic date range.

Ceramics

The assemblage at Granny (site 27) consisted of ninety-three sherds of pottery from at least fourteen vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). The pottery came from two Neolithic structures and from pits and post-holes associated with them. The substantial part of the material (52 sherds) came from the foundation trench of structure 1, or from spreads, pits and post-holes associated with it (29 sherds); this material represents at least eleven vessels. A much smaller amount of pottery (11 sherds) representing at least three vessels came from structure 2. Although the quantity of material from the second structure is small the two groups are sufficiently similar to demonstrate the same form and manufacturing technique and are contemporary assemblages.

Lithics

The lithic assemblage from Granny (site 27) consisted of 4 small pieces of flint debitage, 5 blades and flakes, 1 core, 3 retouched pieces, 2 leaf-shaped arrowheads, 3 convex end scrapers and 1 polished stone axe. The two leaf-shaped arrowheads are particularly fine examples and it is noticeable the one of the few chert artefacts from the area is a large arrowhead. In fact, throughout the southern part of Ireland chert arrowheads tend to be reasonably common and in comparison, to other types of stone tools occur more frequently than might be expected. The relatively small size of the assemblage is also fairly typical of those associated with Neolithic Rectangular Houses.

Archaeobotanical remains

Fragments of carbonised hazelnut shell were identified from many of the samples, albeit in low concentrations. Slightly higher concentrations were recorded from fill C.27239 of deposit C.27238 and fill C.27325 of pit C.27322. A very low concentration of carbonised cereal grain was recovered from just eight of the samples. Only three grains of wheat, identified as emmer wheat were recovered from fill C.27239 of deposit C.27238, while a solitary grain of naked barley was retrieved from fill C.27323 of pit C.27322. A single grain, tentatively identified as oat, was noted from foundation trench C.27124. The preservation of the oat grains did not allow for the separation of the black oat, common oat or the weedy species. The absence of floret bases also hindered any definitive species identification. Indeterminate cereal grains were also identified from foundation trench C.27124, pits C.27138, C.27322, deposits C.27220, C.27238, and C.27245 and post-hole C.27243. Two features contained evidence for carbonised weed seeds fill C.27095 of pit C.27096 and fill C.27098 of burnt spread C.27100. The wild species encountered include several segetal weed taxa often found in waste places or associated with arable land – sheep's sorrel, bladder campion, black bindweed, cleavers, wild mustard and cranesbill.

Radiocarbon dating

Four radiocarbon dates were initially obtained following excavation at Granny (site 27) (see Table B.21). Hazelnut shells from fill C.27325 pit C.27322 in structure 2 returned a date range of 3650-3380 cal BC, oak charcoal from post-hole C.27314 of structure 2 returned a date range of 3960-3710 cal BC, elm charcoal from the cobble spread C.27245 in structure 1 returned a date range of 3770-3630 cal BC and oak charcoal from foundation trench C.27124 of structure 1 returned a date range of 3960-3730 cal BC. Further radiocarbon dates were obtained for Granny (site 27) as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Cereal grains from two fills (C.27323 and C.27325) of pit C.27322 from structure 2 returned date ranges of 3780-3640 cal BC, 3770-3640 cal BC, 3720-3630 cal BC and 3770-3640 cal BC.

Two statistically consistent radiocarbon dates, *UBA-14683* and *UBA-14684* (T'=0.1; T'(5%)=3.8; v=1) (Ward and Wilson 1978) from fill C.27323 of pit C.27322 and two statistically consistent radiocarbon dates *UBA-14685 a*nd *UBA-14686* (T'=0.6; T'(5%)=3.8; v=1) (Ward and Wilson 1978) from fill C.27325 of pit C.27322 were included in the Bayesian model for activity at Granny (site 27). These four dates, along with *UB-6634*, were plotted using OxCal 4.2.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the Early Neolithic occupation at Granny (site 27). The remain three radiocarbon determinations *UB-6633* (oak charcoal), *UB-6635* (elm charcoal) and *UB-6*315 (oak charcoal) have been treated as *termini post quos* for construction. Bayesian modelling returned a date range of *3780-3650 cal BC (95% probability), 3720-3660 cal BC (68% probability)* for the start of occupation at Granny (site 27), and a date range of *3690-3480 cal BC (95% probability), 3650- 3570 cal BC (68% probability)* for the end of occupation ($A_{overall}$=96.9).

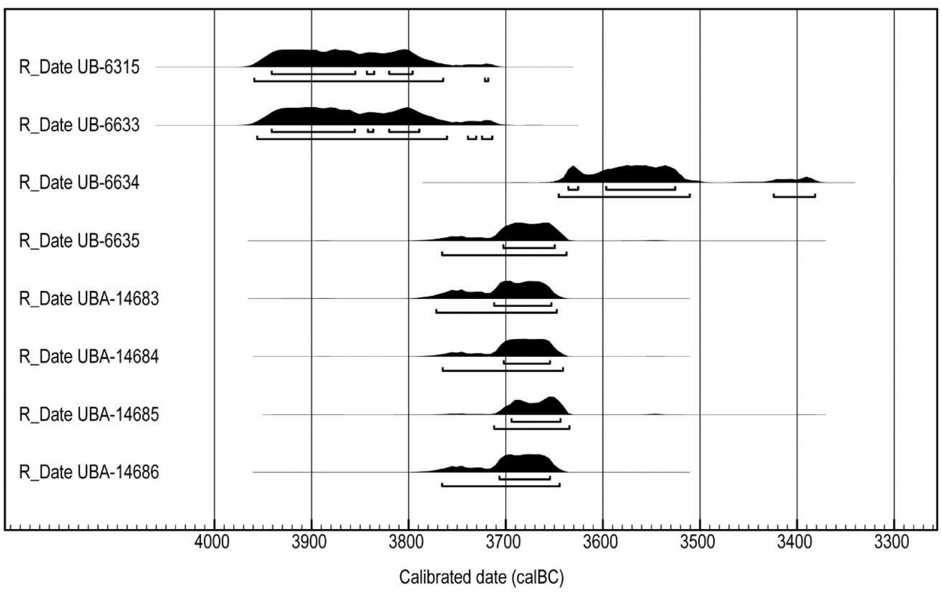

Figure B.57 Calibrated radiocarbon dates from Granny (site 27)

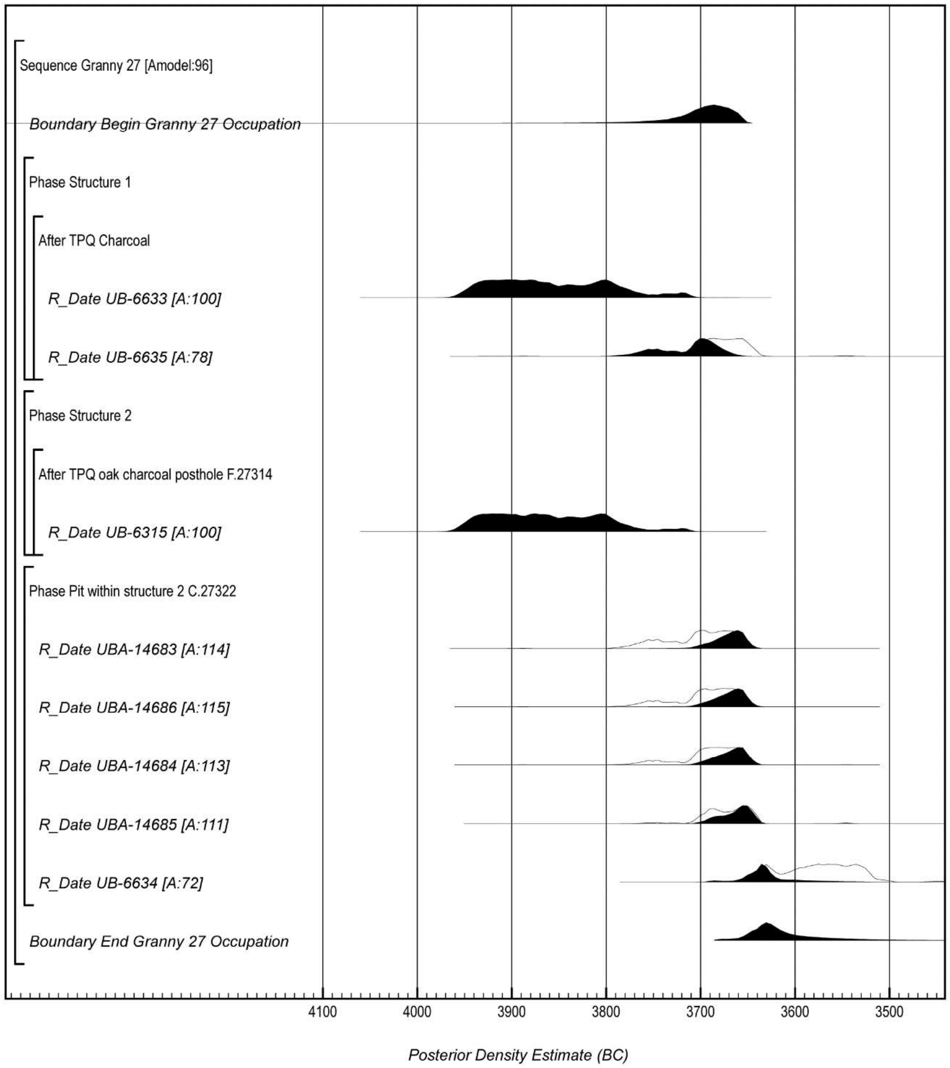

Figure B.58 Bayesian model for occupation at Granny (site 27)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-6315	C.27314	Oak Charcoal	5054 ± 38	3960-3765 cal BC (95.0%) 3722-3718 cal BC (0.4%)	3942-3856 cal BC (50.6%) 3844-3836 cal BC (3.8%) 3820-3796 cal BC (13.8%)
UB-6633	C.27124	Oak Charcoal	5046 ± 39	3956-3761 cal BC (92.6%) 3740-3731 cal BC (1.2%) 3725-3714 cal BC (1.7%)	3942-3856 cal BC (49.2%) 3842-3837 cal BC (2.5%) 3820-3790 cal BC (16.5%)
UB-6634	Fill C.27325 of pit C.27322	Hazelnut Shell	4776 ± 39	3646-3511 cal BC (87.9%) 3424-3382 cal BC (7.5%)	3636-3626 cal BC (8.0%) 3597-3526 cal BC (60.2%)
UB-6635	C.27245	Elm Charcoal	4902 ± 38	3766-3638 cal BC	3703-3650 cal BC
UBA-14683	Fill C.27323 of pit C.27322	Wheat Grain	4926 ± 33	3772-3648 cal BC	3712-3654 cal BC
UBA-14684	Fill C.27323 of pit C.27322	Wheat Grain	4911 ± 32	3766-3642 cal BC	3702-3655 cal BC
UBA-14685	Fill C.27325 of pit C.27322	Cereal Grain	4884 ± 32	3712-3635 cal BC	3694-3644 cal BC
UBA-14686	Fill C.27325 of pit C.27322	Cereal Grain	4918 ± 32	3766-3645 cal BC	3707-3655 cal BC

Table B.21 Calibrated radiocarbon dates from Granny (site 27)

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 96 Aoverall 96.9		
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	C
Sequence Granny 27															
Boundary Begin Granny 27 Occupation							-3712	-3662	68.2	-3779	-3652	95.4			96.8
Phase Structure 1															
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4									
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		100.1	99.9
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3761	-3674	68.2	-3775	-3665	95.4		77.6	99.6
Phase Structure 2															
After TPQ oak charcoal post-hole F.27314	-3830	...	68.2	-3763	...	95.4									
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.2	-3960	-3720	95.4		100	99.9
Phase Pit within structure 2 C.27322															
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3683	-3652	68.2	-3705	-3644	95.4		114.4	99.2
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3681	-3651	68.2	-3703	-3643	95.4		114.6	99.3
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3680	-3650	68.2	-3702	-3642	95.4		113.1	99.3
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3677	-3643	68.2	-3696	-3638	95.4		110.5	99.7
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3657	-3618	68.2	-3691	-3566	95.4		72	98.6
Boundary End Granny 27 Occupation							-3655	-3595	68.2	-3684	-3513	95.4			96.9

Table B.22 Bayesian model for occupation at Granny (site 27)

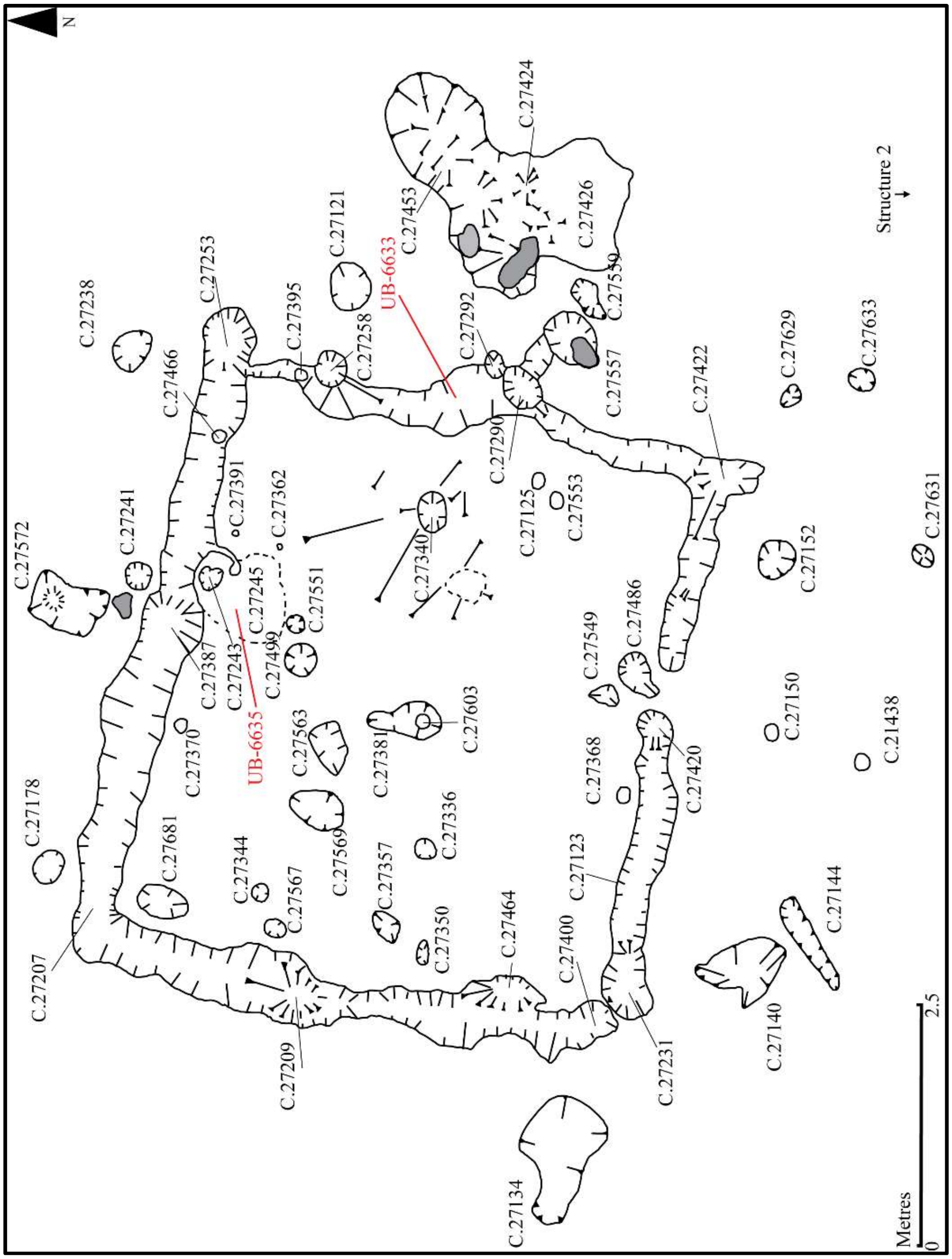

Figure B.59 Neolithic structure 1 from Granny (site 27)

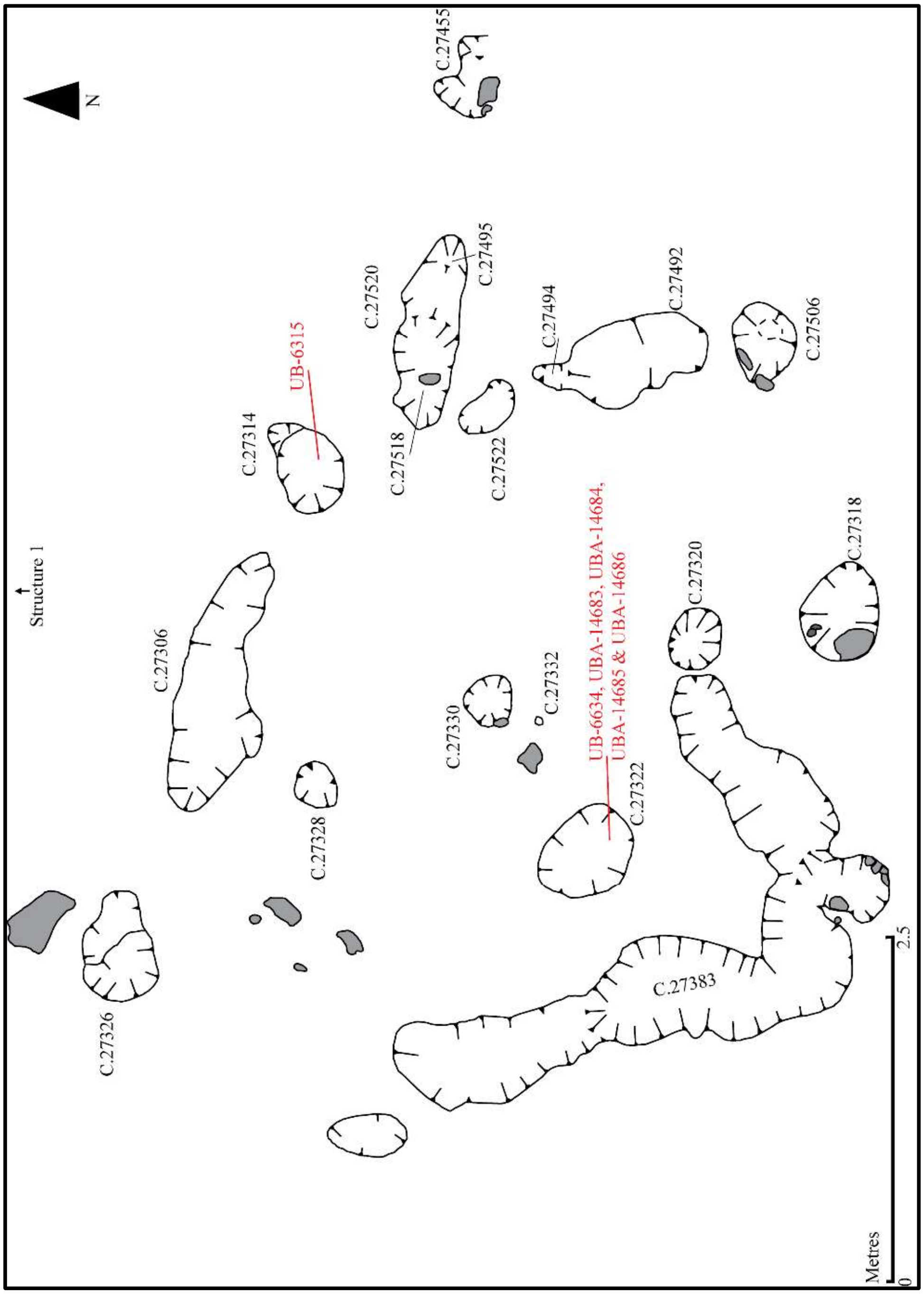

Figure B.60 Neolithic structure 2 from Granny (site 27)

(44) Townland: Gurteen Lower

Barony: Upperthird

County: Waterford

Site Type: Portal Tomb

SMR: WA002-005----

Excavation Licence Number: N/A

ITM: 626279, 623039

National Grid: 226334, 122988

OD: 50-100m

Reference: (Borlase 1897, vol. 1, 56; Ó Nualláin 1983, 102; Moore 1999, 2)

The site is situated in woodland on the floodplain of the River Suir. A portal tomb is oriented east-west and constructed of sandstone boulders. The rectangular roof-stone, measuring *c.*2.90m by *c.*2m and *c.*0.7m in thickness, has slipped off the portal-stones, and the south side-stone is also displaced and now lies across the septalstone, while the south portal-stone has fallen forward. The north portal-stone, measuring *c.*2.2m in height, and the north side-stone, measuring *c.*1.7min height, are undisturbed. The site has not been excavated.

(45) Townland: Jerpoint West

Barony: Gowran

County: Kilkenny

Site Type: Linkardstown single burial

SMR: KK028-060----

Excavation Licence Number:

ITM: 656734, 640926

National Grid: 256795, 140879

OD: 170m

Reference: (Ryan 1973; Brindley and Lanting 1989, 2-3; Power 1993, 15)

The monument at Jerpoint West consisted of a circular mound approximately 24m in diameter, covering a polygonal cist which contained, a cremated and an unburned burial. The mound comprised a central core of stones covered by a thick deposit of soil mixed with sods. The perimeter of the tumulus was defined by a kerb of small limestone flags which played no part in supporting the mound.

The Cist

The cist was polygonal in form, with five major side-stones. Three of the corners were partly closed by smaller stones. Four of the side-stones had additional slabs resting against them externally, giving a double-walled appearance to parts of the structure. The stones of the cist were socketed into the old ground surface. The maximum dimensions of the floor of the cist were *c.*2.14m by *c.*1.87m. The maximum height from the top of the cist to the old ground level was 1.19m. The cist was roofed by a single capstone, two subsidiary capstones rested partly on it. Within the cist an extended burial was visible. It was orientated roughly north-south and was deposited towards the eastern side of the cist. Some rib-bones had been displaced and lay along the eastern side of the cist, otherwise the skeleton was articulated. Fragments of a decorated pottery vessel and a fragment of a pin of polished bone were visible on the surface of the cist deposit. On the surface of the upper fill, near the centre of the cist, there was a thin deposit of cremated Sherds of pottery and some unburned human bones were found in this layer. Sherds of plain pottery were recovered from the lower fill. The vacant space in the sockets was filled by similar material to that comprising the lower stratum of the fill of the cist. A few scraps of decorated pottery came from the top fill of the sockets of the eastern and northern side-stones. Other finds from the cist included sherds of plain pottery, half a small leaf-shaped flint arrowhead and bones of rabbit.

Ceramics

Forty-four sherds and a large quantity of crumbs of a decorated Neolithic vessel, two of which had evidence of lugs were identified. Most of the sherds of this pot were found on, or just beneath, the surface of the upper layer of the fill of the cist mainly in the vicinity of the head of the skeleton, although some fragments were found against the side walls in the north western sector of the cist. In addition, twenty sherds of plain Neolithic pottery were found. Five sherds were discovered lying on the upper surface of the cist fill, fourteen from the lower layer of the filling of the cist and one from the spoil left by the bulldozer.

Lithics

The lithic assemblage consisted of a flint flake from the top sod in trench A and a portion of a leaf-shaped flint arrowhead, which was found on the upper layer of the cist fill in the south-western part of the structure.

Bone pin

The head and a portion of the shank of a pin of polished bone was found against the wall of the cist at the north end near the of the skeleton.

Human Remains

An unburnt skeleton and cremated human bone were found in the cist. The unburnt skeleton was that of a young adult male.

Radiocarbon dating

Two radiocarbon dates have been obtained for burial activity at Jerpoint West, however only one relates to the initial phase of activity (see Table B.23). Human bone recovered from the Cist returned a date range of 3694-3370 cal BC.

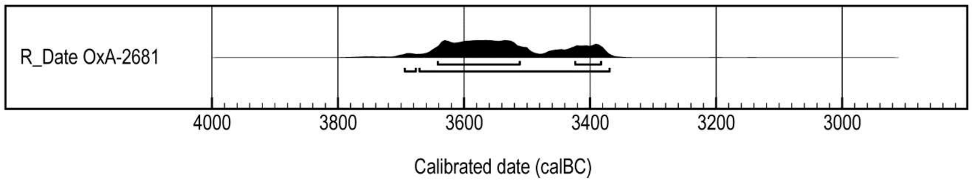

Figure B.61 Calibrated radiocarbon date from Jerpoint West

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
OxA-2680	Cist	Human Bone	4770± 80	3694-3677 cal BC (1.8%) 3671-3370 cal BC (93.6%)	3642-3512 cal BC (55.0%) 3424-3383 cal BC (13.2%)

Table B.23 Calibrated radiocarbon date from Jerpoint West

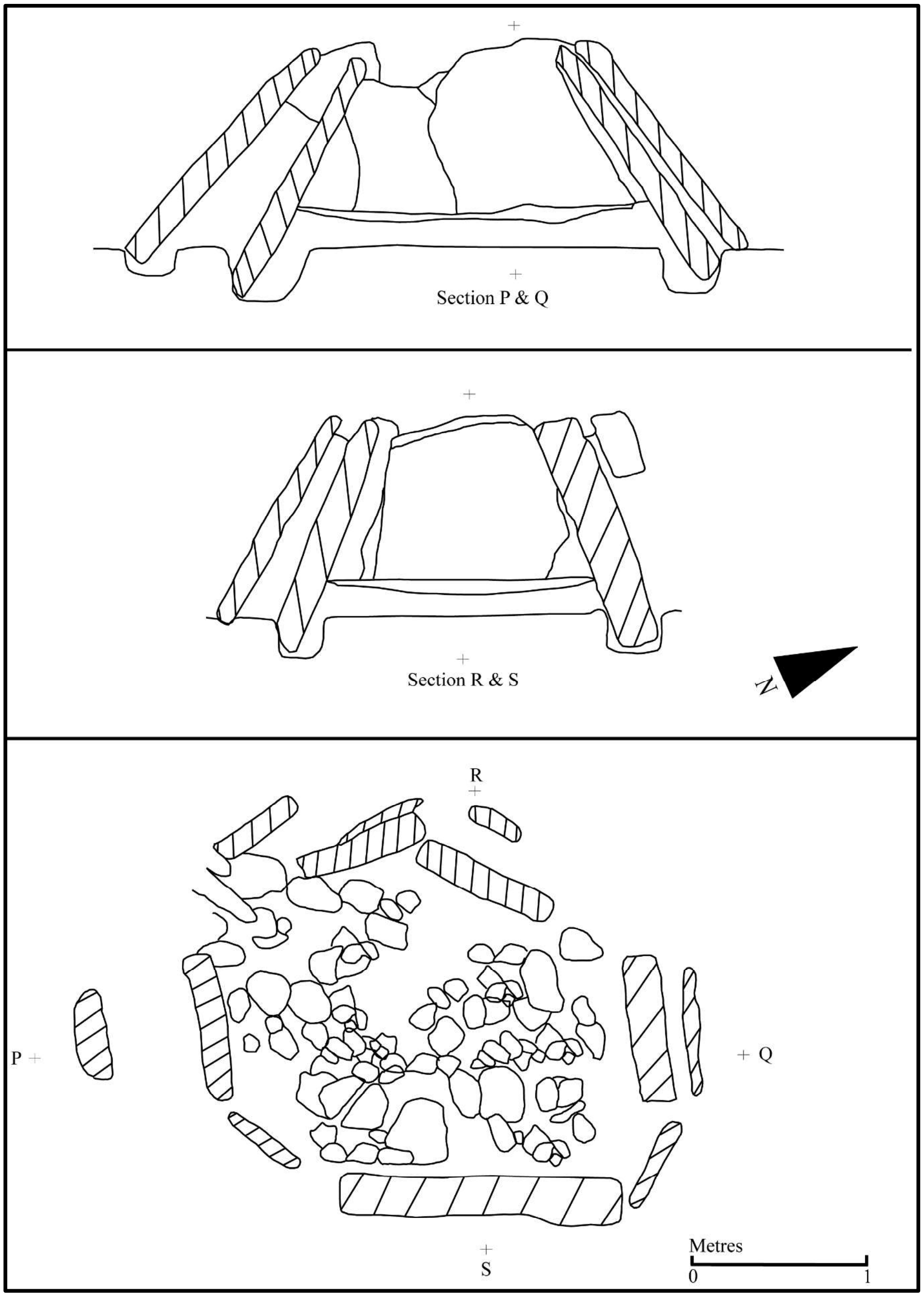

Figure B.62 Linkardstown Burial Cist from Jerpoint West

(46) Townland: Kilgreany Cave

Barony: Decies without Drum

County: Waterford

Site Type: Burial

SMR: WA030-018----

Excavation Licence Number:

ITM: 617567, 594450

National Grid: 217620, 94392

OD: 50-100m

Reference: (Tratman *et al.* 1928; Movius 1935; Molleson 1985-6; Woodman *et al.* 1997; Moore 1999; Dowd 2002)

Kilgreany Cave1, located in the townland of the same name, is one of a number of caves that punctuate a band of Lower Carboniferous limestone that runs east-west through Co. Waterford.

Phase I

The earliest evidence of human activity in Kilgreany Cave relates to C.17, a deposit of brown earth and stones. It survived in the Inner Chamber where it was sealed beneath a stalagmite boss (C.15 and C.16). This deposit (C.17) contained three concentrations of undecorated Early Neolithic pottery sherds. Human bone and bones of extinct species were also discovered in C.17, indicating disturbance of deposits at this level. This floor appears to have been destroyed at a later date, but in the Inner Chamber survived in the form of the aforementioned stalagmite boss (C.15 and C.16). It is likely that this stalagmite boss relates to the same period of calcite deposition as C.8 in the Outer Chamber. Archaeological material of Neolithic date was found directly beneath both C.8 and C.16. Consequently, C.8 and C.16 both appear to have formed portions of the same stalagmite floor. Therefore, the concentrations of Early Neolithic pottery sherds in C.17 in the Inner Chamber are either contemporaneous with, or earlier than, Phase Ib.

Phase Ib

An earlier crystalline stalagmite floor (C.10), predating the stalagmite floor (C.8), survived in the Outer Chamber. It is not possible to establish the chronological relationship between this crystalline stalagmite floor (C.10) and C.17 in the Inner

Chamber as C.10 was not identified in the Inner Chamber and C.17 was not encountered in the Outer Chamber. A black charcoal-rich deposit (C.9) overlay this floor (C.10). The body of an adult male (Kilgreany B was placed on this charcoal-rich deposit (C.9) immediately inside the cave entrance. No grave goods were discovered with the individual. Teeth of two other individuals were recovered from the same charcoal-rich deposit (C.9) though it is impossible to say whether they represent contemporaneous burials or ex situ remains. In 1934, partial remains of a 'small medium sized individual' (Kilgreany U) were also recovered from C.9 indicating at least two primary burials. As the exact location of Kilgreany U was not recorded. A layer of stalagmite (C.8) formed over Kilgreany B and Kilgreany U. A domesticated cattle tibia from C.8 was radiocarbon dated to the Neolithic but predated the underlying crouched burial in C.9, confirming the disturbed nature of the stratification.

Phase II

Stalagmite (C.8) continued to be deposited in the cave, forming another floor which sealed the primary burials (Kilgreany B and U) in C.9. This stalagmite was overlain by another thin, charcoal-rich deposit (C.7). An adult female (Kilgreany A) was placed on the charcoal-rich deposit (C.7) in a tightly flexed position. No grave goods were discovered with the burial. Skeletal remains of other individuals were scattered in proximity, including the remains of an individual who died at approximately 17 years of age (Kilgreany V). This individual may be contemporaneous with Kilgreany A. Two further relatively intact burials (Kilgreany C and D) were placed on the same charcoal-rich deposit (C.7) as the crouched adult female (Kilgreany A). A fragment of a polished stone axe was discovered in proximity to the two inhumations. The stratigraphic link with the crouched adult female (Kilgreany A) indicates that these two burials (Kilgreany C and D) and the stone axe fragment also date to the Neolithic. During the 1934 excavations, the scattered remains of at least three other individuals - a large adult, a small adult and an infant (Kilgreany W, X and Y) - interpreted as badly disturbed burials - were recovered from C.5 and C.6. It is possible that these burials are also Neolithic in date as C.6 contained Neolithic material. If Kilgreany W, X and Y are Neolithic in date, then at least seven burials were placed in the cave during Phase II (Kilgreany A, V, C, D, W, X and y7).

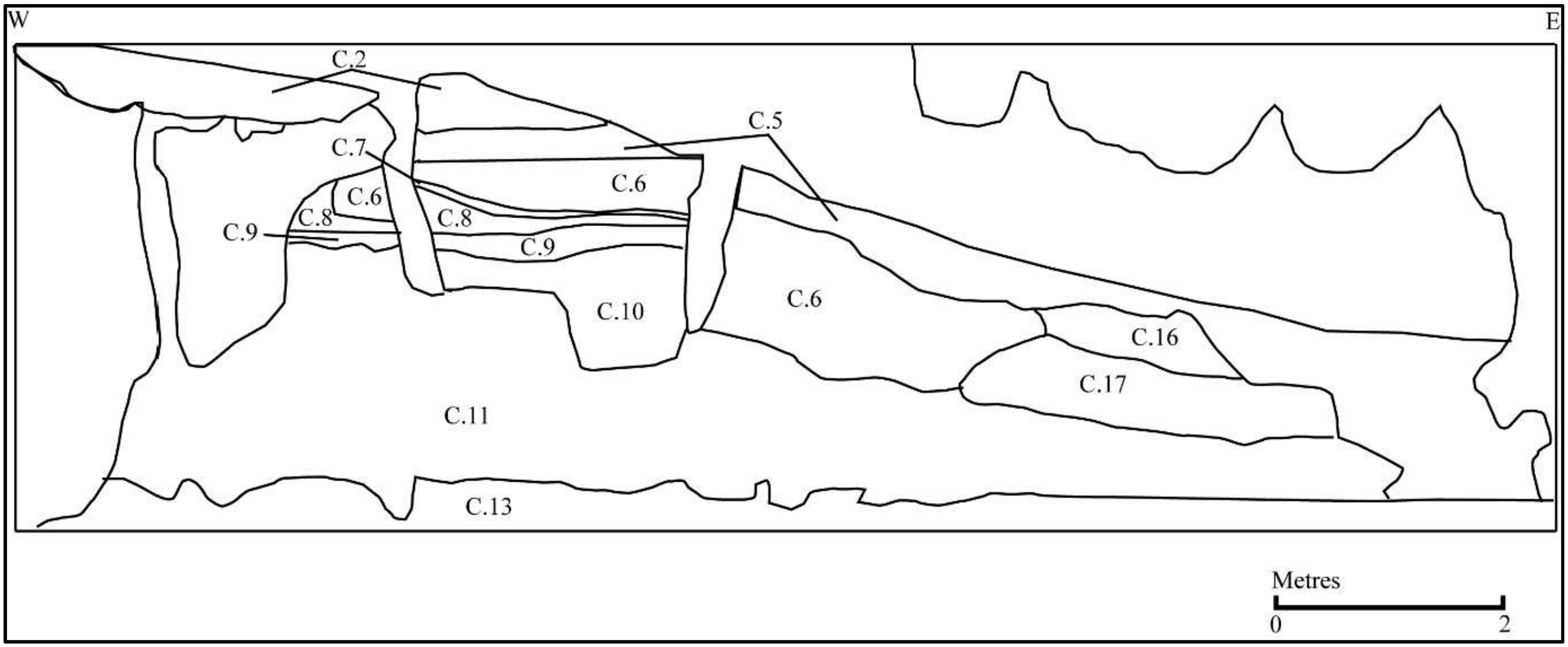

Figure B.63 Kilgreany Cave in section after O'Dowd (2002)

Neolithic artefacts

The axe fragment from C.7 seems to have been associated with one or both of the extended inhumation burials (Kilgreany C and D). Three concentrations of Early Neolithic pottery sherds were located in C.17 in the Inner Chamber. A number of artefacts were recovered from the lower levels of C.6 in Grids C and D, overlying the Neolithic burials on C.7. The Neolithic artefacts include a hollow scraper, six perforated Flat Periwinkle shells, a fish vertebrae bead (species unrecorded) and nine worked or perforated animal teeth (the majority of which were pig teeth).

Radiocarbon dating

Four Early Neolithic radiocarbon date ranges were obtained from Kilgreany Cave (see Table B.24). A human rib bone (Kilgreany A) from C.7 returned a date range of 3640-3119 cal BC, a fragment of a human skull (Kilgreany B) from C.9 returned a date range of 3710-3379 cal BC, and a final date range of 3658-3379 cal BC was also obtained from a human mandible (Kilgreany 3). A cattle tibia from C.8 returned a date range of 4234-3798 cal BC.

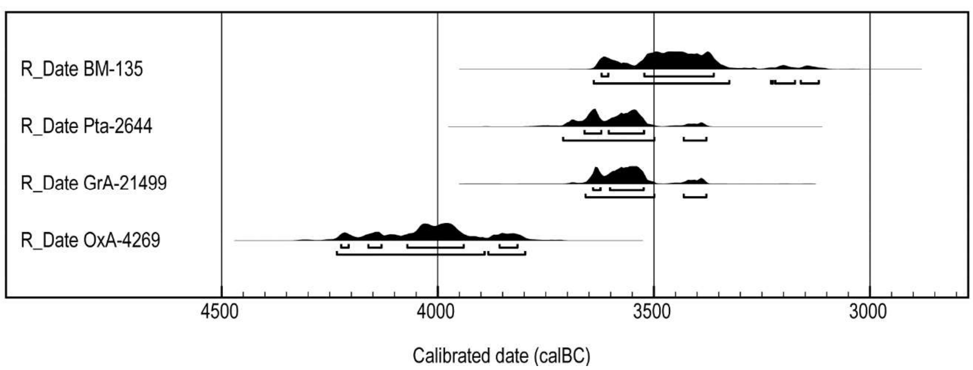

Figure B.64 Calibrated radiocarbon date from Kilgreany Cave

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
BM-135	C.7 Burial A	Human Rib Bone	4660±75	3640-3326 cal BC (89.4%) 3230-3225 cal BC (0.2%) 3220-3174 cal BC (3.1%) 3160-3119 cal BC (2.7%)	3622-3606 cal BC (4.5%) 3522-3362 cal BC (63.7%)
Pta-2644	C.9 Burial B	Human Skull	4820±60	3710-3500 cal BC (88.9%) 3432-3379 cal BC (6.5%)	3661-3622 cal BC (22.3%) 3605-3523 cal BC (45.9%)
GrA-21499	Burial 3	Mandible	4790±50	3658-3500 cal BC (86.0%) 3432-3379 cal BC (9.4%)	3641-3624 cal BC (11.6%) 3602-3524 cal BC (56.6%)
OxA-4269	C.8	Cattle tibia	5190±80	4234-3892 cal BC (81.3%) 3884-3798 cal BC (14.1%)	4224-4207 cal BC (3.7%) 4161-4131 cal BC (6.7%) 4071-3941 cal BC (49.5%) 3858-3816 cal BC (8.2%)

Table B.24 Calibrated radiocarbon date from Kilgreany Cave

(47) Townland: Killaclohane

Barony: Trughanacmy

County: Kerry

Site Type: Portal tomb

SMR: KE047-052----

Excavation Licence Number: 14E0103

ITM: 484616, 601648

National Grid: 84640, 101591

OD:

Reference: (Connolly 2015; Walsh 2015)

The site is situated on north facing slope on south side of the broad valley of the River Maine. The monument is aligned north-south with the entrance facing downslope to north. Remains comprise two portal stones and a roof-stone. The portals stand *c.*0.90m apart and both lean markedly to the east. The west portal if erect, would be *c.*1.60m high, while the east portal if erect, would be *c.*1.70m high. The roof-stone measures *c.*3.75m by *c.*2.60m with a maximum thickness of *c.*0.80m. It is clearly displaced and rests on the E portal. The exact dimensions of the chamber cannot be ascertained with certainty, but it would have been *c.*2m long measuring from the interior edges of the portal stones to where the roof-stone rests on the ground. Other than that, there is no evidence of a surrounding cairn or mound. The monument is undergoing excavation and conservation under the direction of Kerry county archaeologist Dr Michael Connolly however, a detailed report has yet to be published.

Preliminary reports have suggested that the tomb had as complex history and that issues around the stability of the capstone had been addressed during the period of use of the tomb. The tomb produced cremated human remains, numerous pottery fragments, flint artefacts and a broken saddle quern. The pottery indicates that the tomb was in use from the Early Neolithic with a secondary use in the Middle Bronze Age. Analyses of the material from the tomb is ongoing and a full report will be published on completion.

(48) Townland: Kilkeasy

Barony: Knocktopher

County: Kilkenny

Site Type: Neolithic rectangular houses and associated features

SMR: KK035-115----

Excavation Licence Number: E3014

ITM: 651957, 633084

National Grid: 252008, 133048

OD: 110m

Reference: (Monteith 2009; 2010)

The site was identified in advance of roadworks on the N9/N10 Waterford to Kilcullen Road Scheme and was fully excavated between September and December 2006. The foundations of the structure identified at Kilkeasy were represented by slot trenches and post holes. The building was orientated with its long axis, measuring 5m, in an east-west direction. The ground plan consisted of a series of shallow, narrow linear slots trenches to the east, south and north, while post holes/pits defined the western wall, defining an internal area of approximately 22.5m². The foundation trenches of the structure (C.5, C.19 and C.13) were cut in to the natural subsoil C.2, ranging in depth between 0.09m and 0.20m, and formed the eastern, northern and southern wall foundations of the building.

The western wall foundation

The western wall foundation comprised three post holes C.21, C.25 and C.27 which formed a north-south alignment, parallel to eastern wall foundation slot C.5 and perpendicular to slot C.13 of the southern wall.

The eastern wall foundation

The eastern wall foundation was defined by slot trench C.5 and was orientated in a north-south direction parallel to the western wall post hole alignment. To the south at its junction with the southern wall foundation, slot trench C.13, and post pit C.40 formed the south-east corner. A single homogenous fill of orange brown sandy clay C.6 filled this cut. In general, charcoal inclusions in the fills of the structural features were sparse, however a relatively large quantity of oak charcoal was recovered from this fill. A single grain of emmer wheat was also recovered, as were 34 fragments of hazelnut shell. One very small fragment of Early Neolithic pottery was also recovered from this context. Radiocarbon determinations indicate the structure dates to the Early Neolithic period.

The northern wall foundation

The foundation footprint of the northern wall was defined by a shorter slot trench C.19, with a shallow post hole C.23 at its western extent, which may be indicative of the presence of an entrance. Both features contained a light brown clay, C.20 and C.24 respectively, with evidence of charcoal flecking and occasional small pebble inclusions.

The southern wall foundation

The analogous slot trench which formed the southern wall foundation C.13 was orientated in an east-west, direction, perpendicular to slot trench C.5, and parallel to C.19. The eastern extent was defined by a rough alignment of stones. These sub-angular limestone blocks C.53 had an east-west orientation, delimiting the southern line of the slot, where they comprised part of the fill of post pit C.40. A single orange brown sandy clay C.14, similar to that which filled slot C.5, filled this cut.

Pits and post pits

The junction of the eastern and southern wall foundations formed the south-east corner of the structure, where a large sub-circular post pit C.40 was identified. The stone content C.53 exposed on the surface of the uppermost fill of this pit C.41 formed the southern line of slot trench C.13. Towards the centre at the base of this pit a sub-circular shaped post hole C.66, containing a single fill of mid-brownish silty clay C.67, with small sub angular stone inclusions. This feature was sealed by a layer of mid greyish brown silty clay C.41 which covered the base of pit C.40 and incorporated a deposit of large sub-angular stones C.53. An almost identical post pit was recorded to the north of the northern wall foundation. This well-defined cut C.36 this pit had a post hole cut C.54 cutting the natural subsoil base of it. A single mid-orange brown silty clay C.55 containing oak and hazel charcoal filled it. Evidence of the post pipe of C.54 was identified in the primary fill of the pit C.36. The primary fill, C.38 covered the base of the pit and the fill of the post-pipe consisted of dark brown silty clay C.39 with frequent charcoal inclusions and was distinct to that of C.55 which filled the cut beyond the depth of cut C.36. Both worked stone and Early Neolithic ceramic artefacts were recovered from layer C.38. Radiocarbon dating of layer C.38 provides evidence that this feature is contemporary with the structure to the south.

Internal partition

The shallow remains of five cut features were identified within the internal area of the structure. The largest pit C.11 was parallel to the slot trench which comprised the eastern wall C.5 and was juxtaposed to sub-circular cut C.9. Fragments of Early Neolithic pottery were recovered from this context. Their north-south alignment with cuts C.7 and C.17, located to the north, indicates that they are likely to have accommodated posts or stakes that formed part of the internal division. Three additional and smaller cuts were recorded to the north of these features. The largest and most clearly defined was a sub-circular post hole C.7. Fragments of two Early Neolithic vessels were recovered from this context. To the immediate south a stake hole cut C.17 was recorded. A similar well-defined stake hole cut C.15 to the immediate east of C.7, was also identified and would have functioned as part of the internal partition and bore some of the load from the roof.

Associated external features

A number of irregular pits were identified external to the structure which may be contemporary to its use. The hearth C.3 was located to the east of the eastern wall foundation. A single fill consisting of very dark brown sandy clay C.4 filled the hearth and was heavily stained from a high content of charred organic material and oxidized clay. The hearth contained a relative abundance of charred organic material and provides evidence for both cultivated and gathered foods. Charred hazelnut fragments were recovered, grains of emmer wheat, chaff, indeterminate cereal grain fragments and weed seeds were also identified. Lithics and pottery were also recovered from the hearth fill C.4. A Middle Neolithic radiocarbon date was returned from a sample of the hazelnuts, while an Early Neolithic date was returned from one of the wheat grains. Well-defined refuse pit C.29 was identified to the south containing five clearly stratified layers. Artefactual evidence included two slate beads, flint and sherds of Early Neolithic pottery.

Environmental evidence represents both cultivated and gathered foods, fragments of charred hazelnut shells were identified, as well as grains of wheat and other indeterminate cereal grains. Radiocarbon determinations provide an early Neolithic date. Environmental and radiocarbon evidence shows that this feature was contemporary with the house structure and the hearth to the south.

Ceramics

The assemblage at Kilkeasy consisted of seventy-nine sherds of pottery from at least eleven vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). The pottery came from the Neolithic structure and from pits and post-holes associated with it. Six sherds were recovered from the slot trench of the structure, 29 shreds from internal pits C.11 and C.9 and a further two vessels were recovered from internal pothole C.7. The substantial part of the material (5 vessels) came from pit C.29 to the north of the structure, while Early Neolithic Carinated Bowls were also recovered from C.3, C.36, C.49, C.64, C.81 and C.137.

Lithics

The lithic assemblage from Kilkeasy consisted of 62 pieces of worked stone. The material represents activity associated with a rectangular slot trench and a range of external features. From pit C.29, two slate beads and a small slate pendant were recovered in addition to a re-worked and rather crude leaf-shaped flint arrowhead. From pit C.81, a small amount of flint knapping debris was uncovered in association with a simple modified flint blade. As with pit C.29, a small quantity of quartz in the form of three flakes and a fragment were also recovered. Pit C.111 produced another slate bead in association with a flint end scraper and a flake and a small quartz pebble were recovered. Pit C.131 produced only three implements comprising a knife of a rhyolitic rock, a flint end and 1 side scraper and the portion of a blade edge of a re-worked tuff stone axe of possible Group VI (Langdale) type. Pit C.137 produced a small quantity of flint knapping debris and a fine rock crystal flake. Based on the small range of diagnostic forms recovered particularly the Group VI tuff axe, slate beads and leaf arrowhead portion, a date in the Early-Middle Neolithic period is indicated.

Archaeobotanical remains

A small amount of charred plant remains were recovered from the fill of one of the slot trenches and the external hearth. Charred hazelnut shells fragments of were recovered from the hearth C.3, as well as charred grains of wheat. A smaller assemblage of 34 fragments of charred hazelnut shells and wheat grains was identified from slot trench C.5, and external pit C.29, with wheat glume and spikelets also recovered from C.29. Charred hazelnut shells were also recovered from pits C.49 and C.111 to the north of the structure.

Radiocarbon dating

Eight radiocarbon dates were obtained following excavation at Kilkeasy (see Table B.25). Seven samples returned an Early-Middle Neolithic date range while oak charcoal *(Poz-26462*, 4130±40 BP) from C.74 returned a Later Neolithic date. Charred hazelnut shells and a wheat grain from C.29 returned date ranges of 3712-3529 cal BC and 3704-3526 cal BC respectively. Charred hazelnut shells and a wheat grain from slot trench C.5 returned date ranges of 3648-3383 cal BC and 3708-3573 cal BC respectively. Charred hazelnut shells and a wheat grain from C.3 returned date ranges of 3694-3520 cal BC and 3511-3266 cal BC respectively. Hazel charcoal from C.36 returned a date range of 3656-3534 cal BC.

Two statistically consistent radiocarbon dates, *Poz-25458* and *Poz-25458* (T'=0.1; T'(5%)=3.8; v=1) from pit C.29 (Ward and Wilson 1978) and two statistically consistent radiocarbon dates *Poz-25460* and *Poz-25475* (T'=2.3; T'(5%)=3.8; v=1) (Ward and Wilson 1978) from slot trench C.5 were included in the Bayesian model for activity at Kilkeasy. *Poz-25461* and *Poz-25474* from hearth C.3 were shown to be statistically inconsistent (T'=16.5; T'(5%)=3.8; v=1) (Ward and Wilson 1978), *Poz-25474* is likely to be a later intrusion and was therefore also excluded in the model. *UBA-10489* was obtained from hazel charcoal and has been treated as *terminus post quem* for activity at the site. These five dates were plotted using OxCal 4.2.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the activity at Kilkeasy. Bayesian modelling returned a date range of *3690-3530 cal BC (95% probability), 3660-3540 cal BC (68% probability)* for the start of occupation at Kilkeasy and a date range of *3650-3500 cal BC (95% probability), 3650-3530 cal BC (68% probability)* for the end of occupation ($A_{overall}$=131).

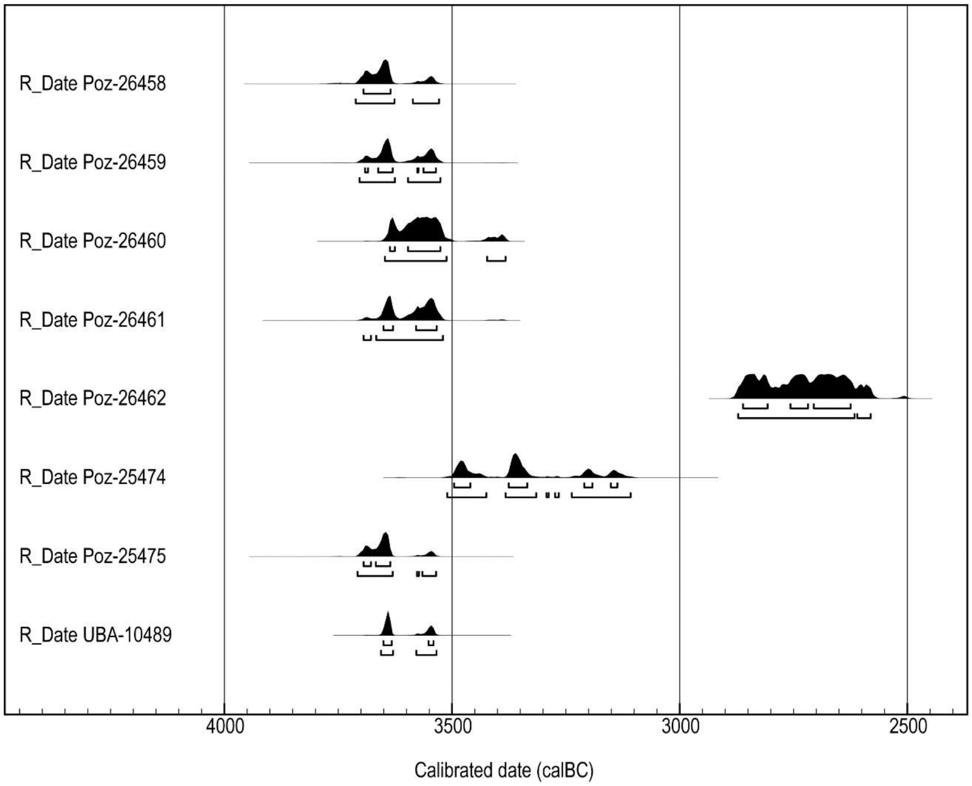

Figure B.65 Calibrated radiocarbon dates from Kilkeasy

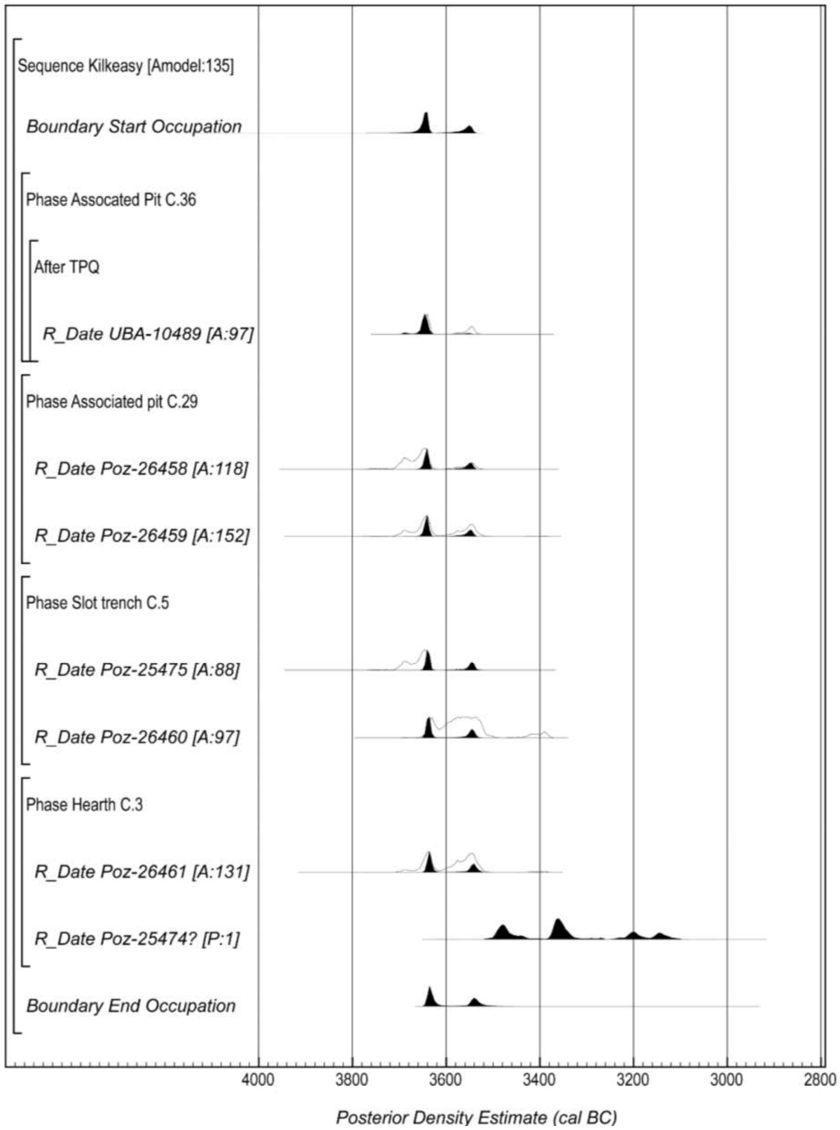

Figure B.66 Bayesian model for occupation at Kilkeasy

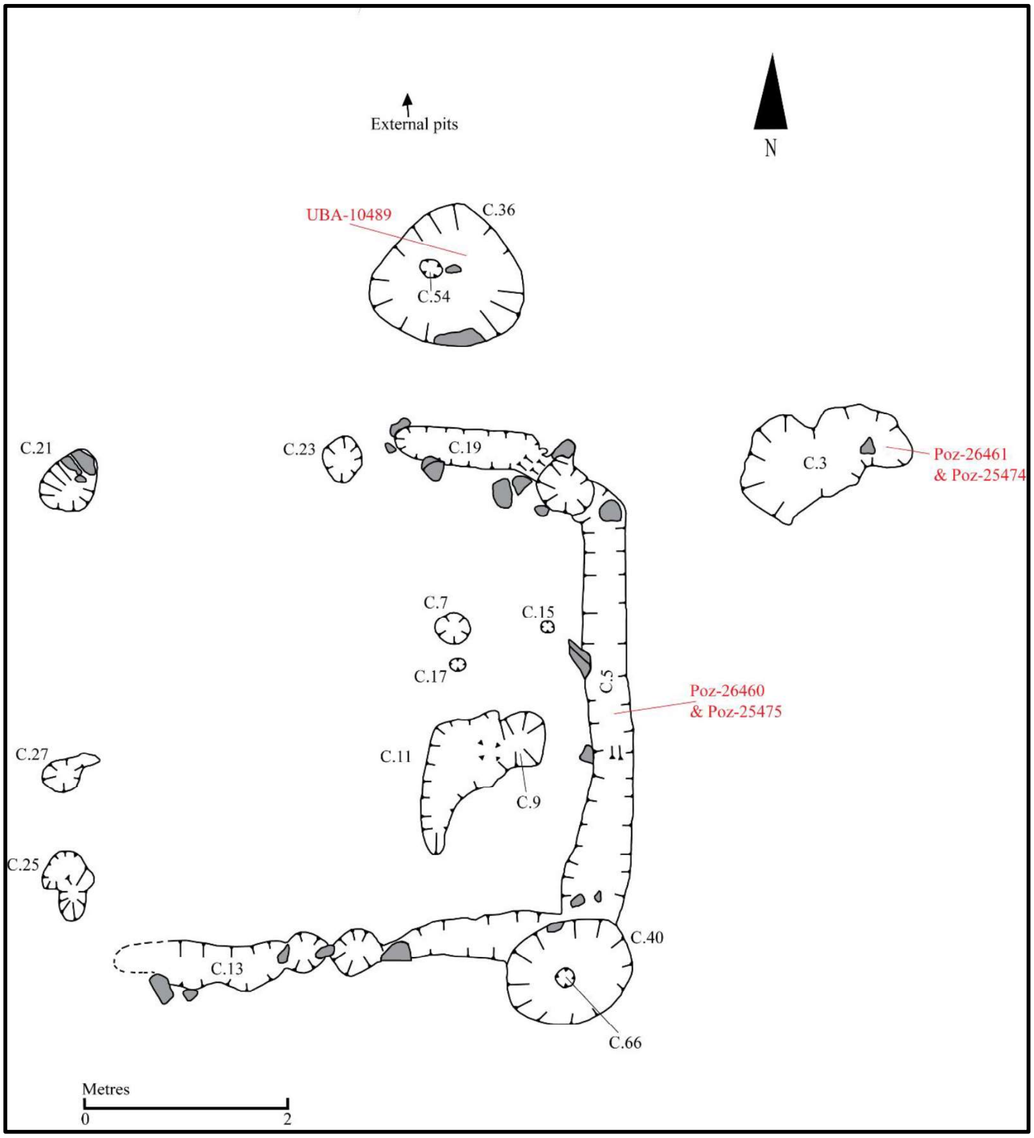

Figure B.67 Early Neolithic structure from Kilkeasy

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Poz-26458	C.29	Hazelnut Shell	4860±40	3712-3627 cal BC (79.3%) 3586-3529 cal BC (16.1%)	3695-3636 cal BC
Poz-26459	C.29	Wheat Grain	4840±40	3704-3626 cal BC (57.5%) 3597-3526 cal BC (37.9%)	3692-3685 cal BC (3.5%) 3662-3631 cal BC (40.3%) 3577-3574 cal BC (1.3%) 3563-3536 cal BC (23.1%)
Poz-26460	C.5	Hazelnut Shell	4780±40	3648-3512 cal BC (88.8%) 3424-3383 cal BC (6.6%)	3637-3626 cal BC (8.7%) 3597-3526 cal BC (59.5%)
Poz-26461	C.3	Wheat Grain	4820±40	3694-3678 cal BC (2.5%) 3667-3520 cal BC (92.9%)	3651-3630 cal BC (23.9%) 3580-3534 cal BC (44.3%)
Poz-26462	C.74	Oak Charcoal	4130±40	2872-2616 cal BC (88.9%) 2610-2581 cal BC (6.5%)	2862-2808 cal BC (20.5%) 2757-2718 cal BC (15.3%) 2706-2625 cal BC (32.4%)
Poz-25474	C.3	Hazelnut Shell	4590±40	3511-3425 cal BC (30.7%) 3383-3316 cal BC (37.8%) 3293-3288 cal BC (0.3%) 3274-3266 cal BC (0.6%) 3238-3108 cal BC (26.1%)	3496-3460 cal BC (22.0%) 3376-3336 cal BC (33.9%) 3210-3192 cal BC (7.2%) 3152-3138 cal BC (5.0%)
Poz-25475	C.5	Wheat Grain	4860±35	3708-3631 cal BC (85.0%) 3578-3573 cal BC (0.6%) 3566-3536 cal BC (9.8%)	3694-3678 cal BC (15.4%) 3668-3636 cal BC (52.8%)
UBA-10489	C.36	Hazel Charcoal	4832±23	3656-3630 cal BC (60.3%) 3579-3534 cal BC (35.1%)	3651-3633 cal BC (51.3%) 3552-3541 cal BC (16.9%)

Table B.25 Calibrated radiocarbon dates from Kilkeasy

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 135.2 Aoverall 131			
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	P	C
Sequence Kilkeasy																
Boundary Start Occupation							-3657	-3545	68.2	-3686	-3538	95.4				98.9
Phase Associated pit C.36																
After TPQ	-3563.5	...	68.2	-3539	...	95.4										
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3655	-3638	68.2	-3696	-3547	95.4		96.5		99.9
Phase Associated pit C.29																
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3650	-3546	68.2	-3656	-3538	95.4		118		99.4
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3650	-3546	68.2	-3656	-3538	95.4		151.8		99.4
Phase Slot trench C.5																
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3646	-3541	68.2	-3651	-3534	95.4		88.1		99.5
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3646	-3539	68.2	-3651	-3530	95.4		97		99.4
Phase Hearth C.3																
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3644	-3538	68.2	-3650	-3523	95.4		131.4		99.2
R_Date Poz-25474	-3496	-3138	68.1	-3511	-3108	95.5	-3496	-3138	68.1	-3511	-3109	95.4			0.5	99.8
Boundary End Occupation							-3644	-3534	68.2	-3650	-3501	95.4				98.1

Table B.26 Bayesian model for occupation at Kilkeasy

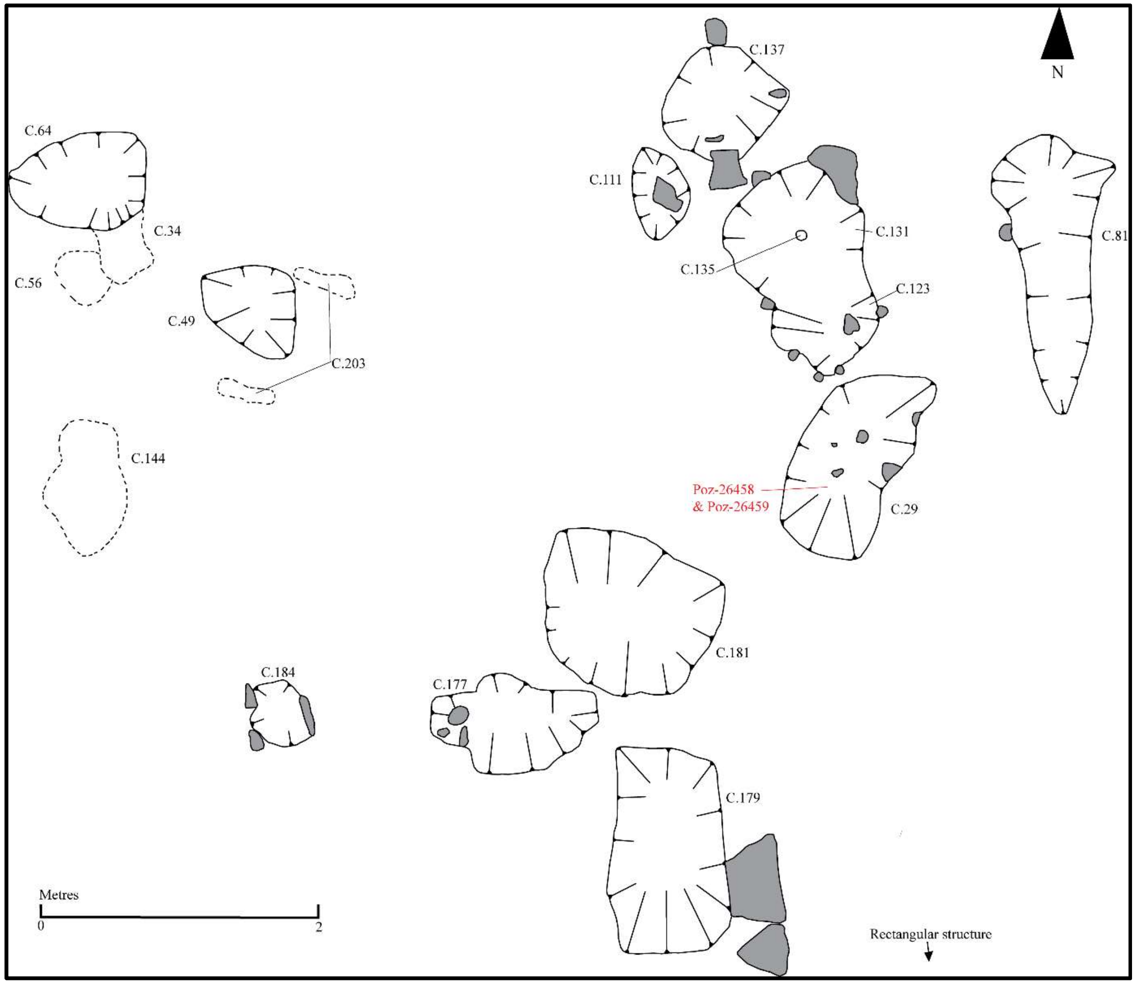

Figure B.68 Associated Early Neolithic features from Kilkeasy

(49) Townland: Killonerry

Barony: Iverk

County: Kilkenny

Site Type: Portal Tomb

SMR: KK038-005----

Excavation Licence Number: N/A

ITM: 641578, 624295

National Grid: 241636, 124244

OD: 0-100m

Reference: (Borlase 1897, 409; Ó Nualláin 1983, 97)

The site is located on flat ground on a hillside, *c.*3km from a tributary of the River Suir to the south-southeast. The structure is partially preserved with a roof-stone measuring *c.*3.75m by 3m with a maximum thickness of *c.*0.9m and a single orthostat *c.*1.2m high. The site has not been excavated.

(50) Townland: Killsheelan

Barony: Iffa and Offa East

County: Tipperary

Site Type: Pit complex

SMR:

Excavation Licence Number: 05E1391

ITM: 628814, 623440

National Grid: 22887, 12339

OD: 20-30m

Reference: (Drum 2007)

The site was identified in advance of a housing development and was fully excavated in January 2006. Pit features were identified in 3 areas of the site.

Area 1

This area measured 10m north-south by 10m east-west and the archaeology in Area 1 comprised 16 cut features consisting of 15 shallow pits and a single stake-hole. Seven pits (C.9, C.13, C.16, C.20, C.22, C.24 and C.26) and a single stake-hole (C.36) were located to the north and centre of Area 1. Pit C.16 was cut by pit C.20. This is the only direct stratigraphic relationship between cut features in this area of the site. Deposition within these pits does not appear to be complicated and most features contained a single fill, although two and three fills were recorded in pits C.13 and C.16 respectively. Pit C.13 contained two fills (C.14 and C.15), both of which contained charcoal. There were also pottery fragments in both fills, with a mixture of different vessels. Both fills of this pit contained hazelnut shell fragments and wheat grains. One of the fills of this pit (C.15) also contained a flint artefact. Charcoal and wheat grains from both fills returned Early Neolithic date ranges.

Pit C.16 was interpreted as a possible hearth and was cut by pit C.20. Two pits (C.26 and C.9) were isolated from this group and the stake-hole C.36 was located 1.5m to the northwest. Pit C.26 was located 0.74m to the south of the main group of pits and was fill by C.27, which contained hazel nut shell fragments and the remains of indeterminate cereals. Pit C.09 was 2.1m to the west of the main group of pits. Located c.3.5m to the west of the north central group was an arc of pits, not very densely grouped. Three (C.3, C.7 and C.11) were oval in plan and two (C.1 and C.28) were circular. No artefacts were included in the fills. Pit C.30 had two fills; the upper most fill was C.31 and the lower fill was C.32, both of these deposits contained sherds of Early Neolithic pottery. Pit C.33 contained two deposits (C.34 and C.35). The lower fill (C.35) also contained fragments of hazel nut shell fragments and indeterminate cereal grains. Pit C.38 contained a single fill (C.39) which had no visible inclusions.

Area 2

A single pit, C.40, was recorded in Area 2, *c*.340m to the east of Area 1. It contained a single deposit (C.41) of grey sandy silt with occasional charcoal flecks and a small quantity of charred cereal fragments and a weed seed.

Area 3

A single feature (C.42) was recorded in Area 3, *c*.300m to the east of Area 1 and 35m to the northeast of Area 2. The fill of the pit (C.43) included 80% large and medium stones and two animal bones. The state of preservation of the bone and the stone fill indicate that the feature was probably associated with modern field clearance.

Ceramics

The assemblage at Killsheelan consisted of seventy-nine sherds of pottery from at least five vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). All pottery was recovered from Area 1 with fragments found in fill C.15 of pit C.13, fills C.31 and C.32 of pit C.30. One vessel was identified as an Early Neolithic cup, this was discovered in fill C.14 of pit C.13.

Lithics

The lithic assemblage consisted of seven pieces and were recovered from the fills of pits C.13 and C.30 in Area 1. Four flint and mudstone blades, two flint and limestone flakes and a flint scraper were identified. The assemblage can be dated to the Neolithic period due to the presence of two lithics which clearly derive from polished stone axes.

Archaeobotanical remains

Small quantities of charred cereals, in particular emmer wheat, and hazelnut shell fragments were found in four contexts, fills C.14 and C.15 of pit C.13, fill C.27 of pit C.26, fill C.35 of pit C.33 (Area 1) and fill C.41 of pit C.40 (Area 2).

Radiocarbon dating

Two radiocarbon dates were initially obtained following excavation at Killsheelan (see Table B.27). Charcoal from fill C.14 and C.15 of pit C.13 returned date ranges of 3704-3526 cal BC and 3771-3637 cal BC respectively. Further radiocarbon dates were obtained for Killsheelan as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Cereal grains from two fills, C.14 and C.15 of pit C.13 returned date ranges of 3696-3532 cal BC, 3651-3521 cal BC, 3647-3389 cal BC and 3651-3518 cal BC respectively.

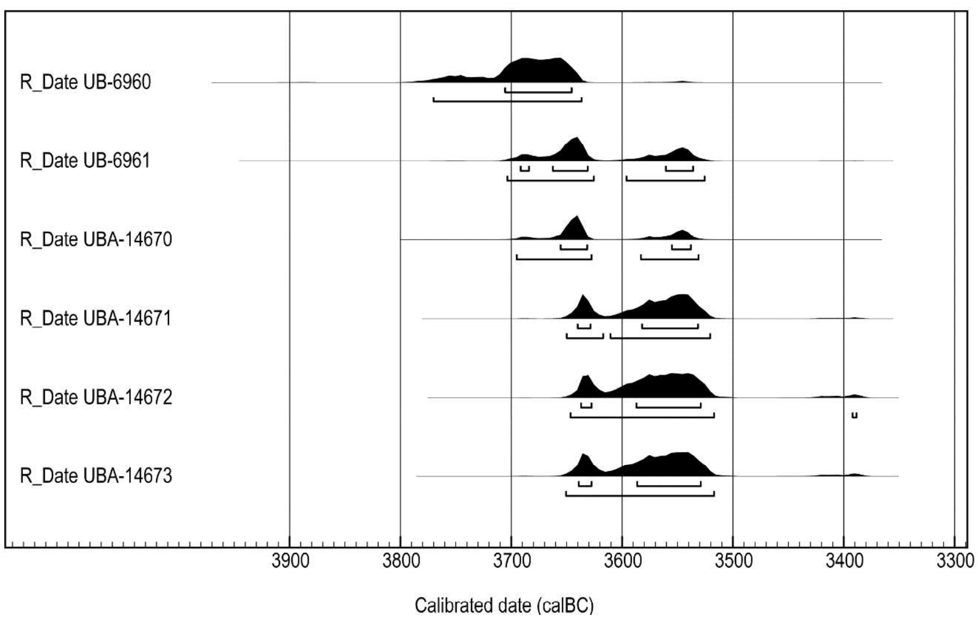

Figure B.69 Calibrated radiocarbon dates from Killsheelan

The radiocarbon date *UB-6961* from fill C.14 of pit C.15, despite being derived from charcoal, was shown to be statistically consistent with *UBA-14670* from fill C.14 of pit C.15 (T'=0.0; T'(5%)=3.8; v=1) (Ward and Wilson 1978) and was therefore included Bayesian model for activity at Killsheelan along with the three radiocarbon dates *UBA-*

14671, UBA-14672 and *UBA-14673* from fill C.15 of pit C.13. *UB-6960*, also from charcoal, was statistically inconsistent with *UBA-14671, UBA-14672* and *UBA-14673* also from fill C.15 of pit C.13 and has been treated as *terminus post quem* for activity at the site. These five dates were plotted using OxCal 4.2.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the activity at Killsheelan. Bayesian modelling returned a date range of *3700-3530 cal BC (95% probability), 3660-3540 cal BC (68% probability)* for the start of occupation at Killsheelan and a date range of *3650-3470 cal BC (95% probability), 3640-3520 cal BC (68% probability)* for the end of occupation ($A_{overall}$=115).

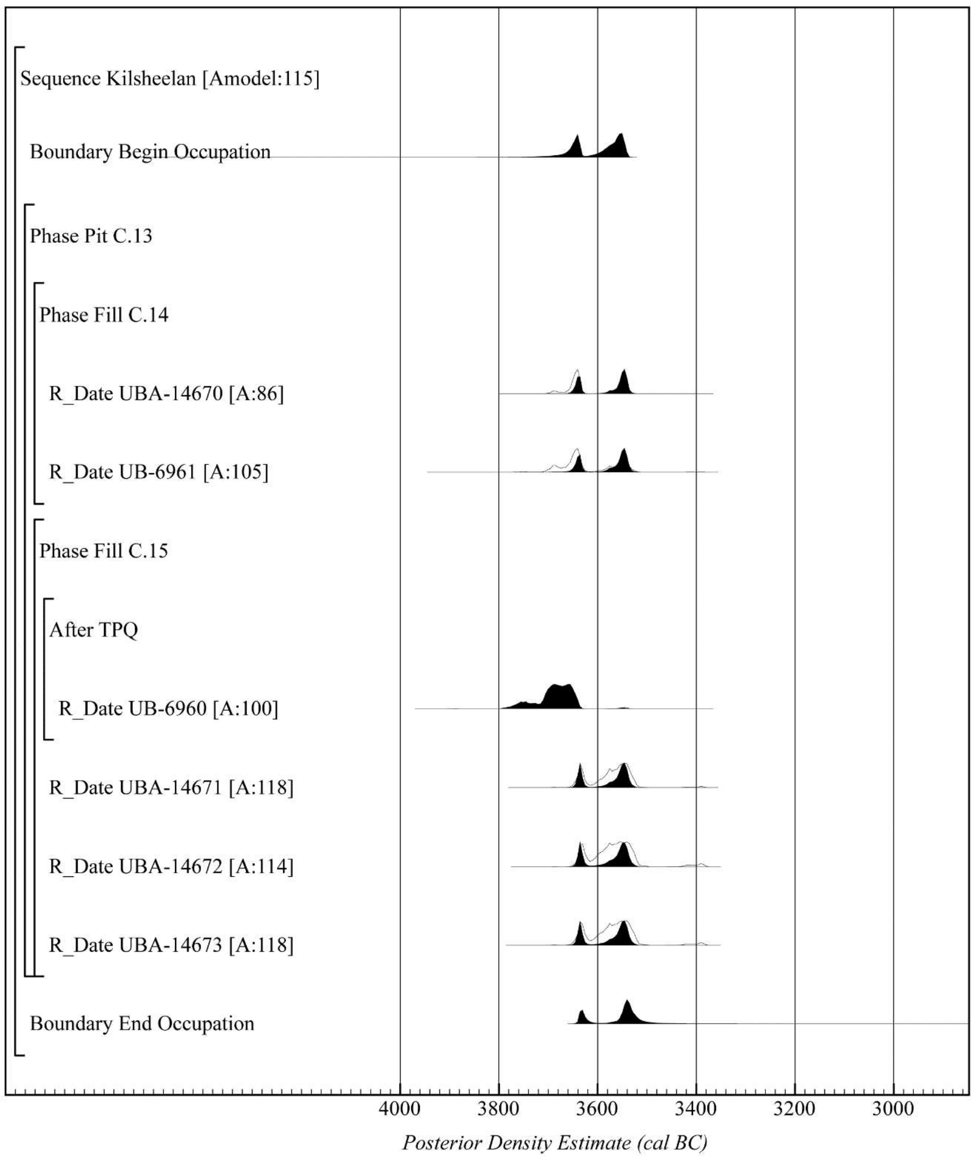

Figure B.70 Bayesian model for occupation at Killsheelan

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-6960	Fill C.15 of C.13	Charcoal	4900±41	3771-3637 cal BC	3706-3646 cal BC
UB-6961	Fill C.14 of C.13	Charcoal	4841±39	3704-3626 cal BC (59.2%) 3597-3526 cal BC (36.2%)	3692-3685 cal BC (4.2%) 3663-3632 cal BC (42.5%) 3561-3537 cal BC (21.6%)
UBA-14670	Fill C.14 of C.13	Emmer Wheat Grain	4839±30	3696-3628 cal BC (63.7%) 3584-3532 cal BC (31.7%)	3656-3632 cal BC (49.8%) 3556-3539 cal BC (18.4%)
UBA-14671	Fill C.15 of C.13	Emmer Wheat Grain	4799±33	3651-3618 cal BC (20.8%) 3611-3521 cal BC (74.6%)	3641-3629 cal BC (12.4%) 3583-3532 cal BC (55.8%)
UBA-14672	Fill C.15 of C.13	Emmer Wheat Grain	4786±34	3647-3518 cal BC (94.9%) 3393-3389 cal BC (0.5%)	3638-3628 cal BC (9.1%) 3588-3530 cal BC (59.1%)
UBA-14673	Fill C.15 of C.13	Indeterminate Cereal Grain	4793±36	3651-3518 cal BC	3640-3628 cal BC (10.9%) 3587-3530 cal BC (57.3%)

Table B.27 Calibrated radiocarbon dates from Killsheelan

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 115.1 Aoverall 115.4		
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	C
Sequence Killsheelan															
Boundary Begin Occupation							-3654	-3544	68.2	-3698	-3537	95.4			97.3
Phase Pit C.13															
Phase Fill C.14															
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3645	-3539	68.2	-3654	-3533	95.4		85.5	98.9
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3646	-3537	68.2	-3657	-3530	95.4		104.9	98.9
Phase Fill C.15															
After TPQ	-3666	...	68.2	-3642	...	95.4									
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3768	-3637	95.4		100.3	100
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3642	-3537	68.2	-3649	-3528	95.4		117.9	98.8
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3641	-3536	68.2	-3647	-3526	95.4		113.7	98.8
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3642	-3537	68.2	-3649	-3526	95.4		117.8	98.8
Boundary End Occupation							-3639	-3522	68.2	-3645	-3479	95.4			98.1

Table B.28 Bayesian model for occupation at Killsheelan

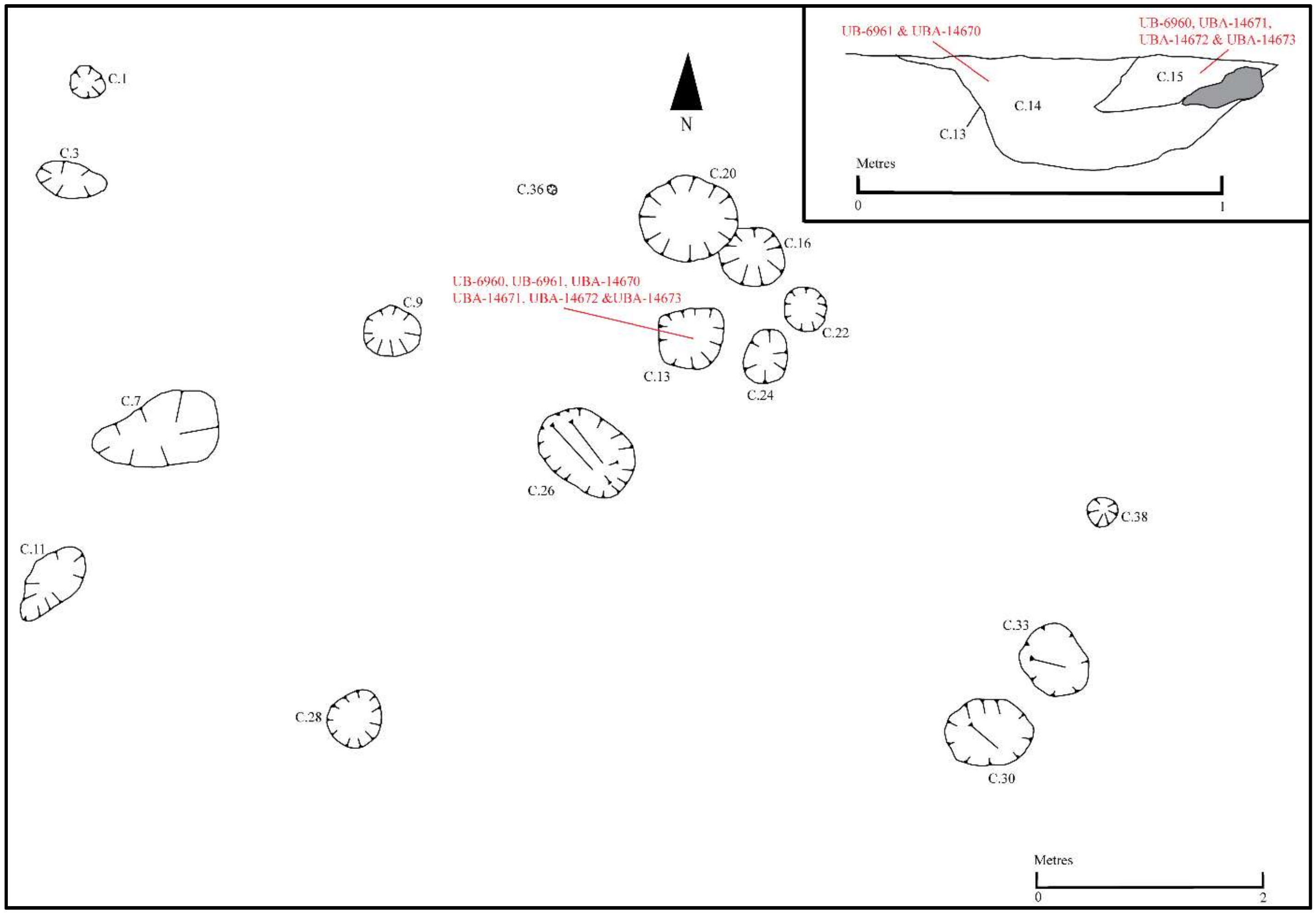

Figure B.71 Early Neolithic features from Area 1, Killsheelan

(51) Townland: Kilmogue

Barony: Knocktopher

County: Kilkenny

Site Type: Portal Tomb

SMR: KK035-044----

Excavation Licence Number: N/A

ITM: 650193, 628215

National Grid: 250253, 128165

OD: 600-700m

Reference: (Borlase 1897, 405-407; Ó Nualláin 1983, 97)

The site is located in flat pasture above the head-waters of a tributary of the River Suir and *c.*16km north-west of their confluence. The chamber has a high-pitched roof resting on the horizontal roof-stone. The upper roof-stone measures *c.*4.4m by *c.*3.1m and is *c.*0.8m thick while the lower roof-stone measures *c.*2.1m by *c.*1.7m and *c.*0.3m thick. The roof-stones rest on two portal-stones and a door-stone. The north portal-stone is *c.*3.6m in height and the south portal-stone is *c.*3.5m in height. The door-stone is *c.*3.1m in height. The site has not been excavated.

(52) Townland: Knockeen

Barony: Middlethird

County: Waterford

Site Type: Portal Tomb

SMR: WA017-034----

Excavation Licence Number: N/A

ITM: 657473, 606524

National Grid: 257534, 106469

OD: 100-200m

Reference:(Du Noyer 1866, 479; Atkins 1896, 69-70; Borlase 1897, 61-62; Anon 1912, 279; Harbison 1992, 326; Ó Nualláin 1983, 103; Moore 1999, 3)

The site is situated on a gentle south facing slope, *c.*4.8km south-east of the River Suir and *c.*5km from Tramore Bay and faces north-west. It is complete with two roof-stones, the upper roof-stone measures *c.*3.9m by *c.*2.2m and *c.*1.1m in thickness, the lower roof-stone is *c.*2.6m by *c.*2.4m and *c.*0.6m in thickness. The upper roof-stone rests on the two portal-stones *c.*2.7m and *c.*2.6m high, a door-stone *c.*2.3m high is also present. The site has not been excavated.

(53) Townland: Lisduggan North

Barony: Duhallow

County: Cork

Site Type: Linkardstown type burial

SMR: CO023-293----

Excavation Licence Number:

ITM: 543206, 603152

National Grid: 143243, 103096

OD: 91m

Reference: (Cahill and Brindley 2011)

The site was identified during preparation of cliff face for quarry blasting in 1946. Skeletal remains of two adults were recovered with four sherds of prehistoric pottery Although details of the burial are poorly documented, Brindley and Lanting (1989, 3) suggest that this may be an 'orthodox burial of Linkardstown Type.' An Early to Middle Neolithic radiocarbon date was obtained from the unburnt skeletal remains.

Ceramics

The assemblage at Lisduggan North consisted of four sherds of decorated pottery from at least 1 vessel and a further undecorated sherd of a second vessel which has been lost. The pottery likely dates to the Middle Neolithic and is of the ‘Linkardstown Type tradition.

Radiocarbon dating

A single radiocarbon date was obtained from unburnt human bone and returned a date range of 3626-3029 cal BC (see Table B.29).

Lab Code	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
OxA-2681	Human Bone	4585±80	3626-3596 cal BC (2.2%) 3526-3086 cal BC (91.2%) 3062-3029 cal BC (2.0%)	3500-3430 cal BC (17.8%) 3380-3314 cal BC (18.4%) 3294-3288 cal BC (1.0%) 3274-2366 cal BC (1.5%) 3238-3108 cal BC (29.6%)

Table B.29 Calibrated radiocarbon dates from Lisduggan North

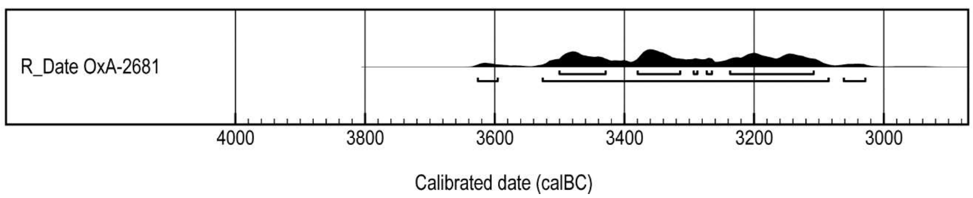

Figure B.72 Calibrated radiocarbon dates from Lisduggan North

(54) Townland: Lough Gur

Barony: Smallcounty

County: Limerick

Site Type: Neolithic structures, burials, enclosures

SMR: LI032-022004-, LI032-022005-, LI032-022006-, LI032-022032- (various)

Excavation Licence Number:

ITM: 564032, 640631

National Grid: 164073, 140583

OD:

Reference: (Ó Ríordáin 1954; Grogan and Eogan 1987; Cleary 1993; 1995; 2000; 2003; 2018; Smyth 2014, 71-81)

The following provides an overview of the Early Neolithic activity from the Lough Gur/Knockadoon South area based on the recent reassessment by Rose Cleary (2018).

Site A Knockadoon

This site was at the foot of the lower south-west slope of Back Hill on Knockadoon. The house was rectangular in plan with a north-south long axis and the site slope resulted in the south end being *c.*0.6m lower than the north end. The overall internal dimensions were *c.*6.1m by *c.*9.75m. The stone footing was continuous along the perimeter except on the south-west corner where the entrance was located. Paired post-holes were s*et al*ong the external and internal perimeters of the stone footing. These perimeter post-holes marked the line of upright posts which possibly had intermediary wattle walls forming the shell of the house wall between the posts.

Ceramics

The pottery was identified as Neolithic Class I ware. Class I wares were round-based with angled profiles and undecorated, typical of Neolithic pottery. Most of the pottery came from the north-east area of the house around the hearth.

Lithics

The lithic assemblage from Site A comprised an almost complete greenstone axe-head four axe-head chips which were re-used as scrapers and a slate spearhead. The axe-head was found under the inner side of the northern stone foundation and may have been deliberately placed there or perhaps casually used as a convenient stone. Eighty-six, mainly flint artefacts, of were also recovered including two leaf-shaped arrowheads scrapers and blade tools.

Site B Knockadoon

Site B was south-west of Site A, nearer to the lakeshore and on the same ridge as Sites A, C and D. Post-holes under a stone foundation course on the south side and on the west and north sides and a single post-hole on the east side mark the ground plan of the primary building. The east/west axis of the house was *c.*7m in length and the house was *c.*6m north/south. Phase 2 of the building was possibly a partial reconstruction of the earlier house and comprised a *c.*6.1m long stone foundation course along the south side and a foundation trench for a plank-built wall on the north side. Paired post-holes were recorded on either side of the stone foundation and similar to Site A these must have held structural posts for the second phase of wall construction and also provided roof supports. A trench along part of the north side which turned at the north-east corner was probably a foundation for a plank-built wall. This trench terminated on the east side at a large post-hole. Internal post-holes may indicate an internal division and structural posts used as roof supports; these may have been part of Phase 1 or Phase 2 house construction.

Ceramics

The pottery from Site B was almost exclusively Neolithic and comprised plain (Class I) and decorated wares (Class Ia). Most of the 650 sherds of pottery came from the northeast quadrant of the house floor. The pottery was round-based with sharp shoulders and either plain or decorated rims or some vessels had lugs or short handles at the shoulders.

Lithics

One complete stone axe-head, two butt ends of stone axe-heads and eight fragments were recovered at Site B. Fifty-six pieces of struck flint, chert and quartz were found at Site B. Two leaf-shaped arrowheads, one blade and one scraper were recovered.

Archaeozoological remains

The archaeological assemblage was identified as cattle, sheep or goat and pig. Red deer bones were also recovered. Bones of a dog/wolf may have been a pet. Bird bones were from barnacle geese and mallard, presumably caught when the opportunity arose and consumed on site.

Circle K

Circle K was situated on a level plateau on the west side of Knockadoon Hill. The enclosure wall and stone footings of a central house were visible before excavation. The site had two houses, one under the enclosure wall and an off-centre house within the enclosure. There was also evidence of burial on the site.

Ceramics

Fifty-eight sherds of Class I pottery which were part of four vessels within Circle K, while an additional 167 fragments of Class I pottery which were from at least six vessels were recovered from the vicinity of House 1

Lithics

The lithic assemblage of Circle K included 56 flint and chert artefacts; eight leaf- and lozenge-shaped arrowheads, eleven scrapers, fragments of flint and chert knives and blades. Two complete stone axe-heads were also recovered. There was also debitage from on-site flint and chert working. A granite axe-head and axe-heads chips was recovered from the vicinity of House 1.

House 1

House I was under the north-east quadrant of the Bronze Age stone enclosure and in a saucer-shaped natural hollow. The house was roughly square in plan and measured *c.*7.25m by *c.*6.65m. A gravel bank topped with stones formed the base of the north and east walls. A line of post-holes along the southern side may have marked the south wall or an internal division if the house floor continued under the later enclosure wall. Two extant post-holes were recorded along the west wall. A gap in the north wall with a post-hole on the west side may have marked the entrance. A large internal post-hole towards the north end and a smaller post-hole at the south end may have contained posts for internal roof-supports.

Ceramics

The pottery from the house was identified as Class I and fragments of at least six vessels were recovered.

Lithics

The lithic assemblage from the House 1 included one laurel-shaped arrowhead, six leaf-shaped arrowheads and a roughout for a lozenge-shaped arrowhead. Seventeen scrapers, two knives and five blades were also recovered. Two greenstone axe-head fragments and one granite axe-head fragment as well as some axe-head chips were found. Three beads were found within the house.

Burials

Five burials were recorded in the environs of House 1, Circle K. There was no evidence that the burials were associated with house construction or use. There is no absolute dating of the burials, but it is clear from the published information that not all the burials were contemporary interments, and some were later than others.

House 2

The house was within the enclosure, off-centre and mainly in the south/east quadrant. The house was rectangular in plan and measured *c.*8.2m and *c.*6.4m. An earthen bank on which were placed stones was recorded at foundation level. Post-holes, some of which were paired were recorded on either side of the foundation and presumably held structural posts which formed the wall and supported the roof. Two large post-holes which were slightly off-centre may have provided additional internal roof supports. The entrance was marked by a 0.8m wide gap in the east wall.

Ceramics

Sherds from at least nine vessels of Class I pottery were recovered mainly from the south-east corner of the floor are.

Lithics

The struck stone tools were six scrapers, a blade, two knives, one leaf-shaped and one lozenge-shaped arrowhead. One almost complete greenstone polished axe-head and small chips of a sandstone stone axe-head.

Burials

Two infants were buried in shallow graves in the floor of House 2. A child burial in a shallow grave was also recorded immediately outside the north-eastern wall of House 2. Two child burials were also recorded between House I and 2.

Circle L

The site on the south-east side of Knockadoon Hill. The enclosure wall at Circle L, similar to Circle K probably post-dated Neolithic activity on the site.

Ceramics

The ceramic assemblage comprised fragments of at least 40 vessels of which 25 were from the primary occupation or pre-enclosure phase. All were undecorated and suggest early Neolithic Class I ware. The majority of the pottery was from north of House A or in the vicinity of the Central House

House A

This was on the north side of the enclosure and best-preserved on the north-east corner. The southern side of House A was under Phase 1 of the Central House and the construction of the Central House disturbed some of the structural features of House A. The floor plan of House A suggests a square or rectangular building. The structural elements were a double row of paired posts forming the external walls probably with intermediary double wattle walls with an organic layer between the wattles. A pit in the northeast corner was of sufficient size to hold a substantial corner post for the building.

House B

This was on the south side of the enclosure and was best-preserved on the south and west sides. The floor plan suggests a rectangular building. The structural features included the vestiges of a west wall and part of the south-west wall constructed from a double row of posts and a slot trench along the south wall perhaps used to house a plank-built wall. A large post-hole adjacent to the inner edge of the slot-trench may also have held a roof support post.

Central House (Phase 1)

This was built later than House A as a habitation layer of the Phase 1 Central House overlay the post-holes of House A. The structural remains of the Central House were poorly-preserved and the main evidence for a house were post-holes on the east side and a line of large post-pits on the west side.

Ceramics

Neolithic pottery (Class I) was recovered from the burnt area near the east wall.

Site 10

Site 10 was on a level platform on the south-west of Knockadoon Hill. The primary occupation phase of Site 10 was a charcoal-rich layer of habitation material that extended under the later enclosing wall and included Neolithic pottery, stone tools and axe-heads, bone points and beads.

Ceramics

The pottery from Site 10 was primarily Class I ware and fragments of at least 35 vessels were recovered. Only three sherds of decorated Neolithic pottery (Class Ia) were recovered.

Lithics

The lithic assemblage comprised flint and chert artefacts and some waste from on-site knapping. Seventeen flint and chert leaf- and lozenge-shaped arrowheads were found in the Neolithic habitation layer, this layer also produced 40 scrapers including round, end and side scrapers, knives and blades. Three complete and five large fragments of polished stone axe-heads made from tuffs and greenstone were found in the Neolithic layer.

Site 12

This was located on the west side of Knockadoon Hill. The site was enclosed on the east side by a curved wall which formed a D-shaped enclosure and the west side was at the top of a cliff. The site was relatively level on the west side but sloped upwards towards the east.

Ceramics

The excavation recovered fragments of six Class I vessels.

Lithics

The lithic assemblage consisted of one lozenge-shaped and four leaf-shaped arrowheads, scrapers, fragments of six polished stone axe-heads as well as evidence of on-site production of flint and chert tools.

Circle J

This site was on a level platform in the centre of Knockadoon Hill. The Neolithic phase at Circle J comprised two pits with adjacent clusters of post-holes and two post-holes to the north of the main group. The post-holes were possibly the remains of a Neolithic house of square or rectangular plan. The internal pits may have held posts for roof supports. Two other spreads of Neolithic habitation material were on the north-east outside the enclosure wall.

Ceramics

The pottery from the Neolithic level at Circle J included fragments of at least five Class I vessels.

Lithics

The lithic assemblage consisted of leaf-shaped arrowheads, fifteen scrapers, knifes, blades and points and debitage from on-site flint and chert working. Five stone axe-head fragments were recovered in the Neolithic layer; four stone axe-heads, axe-head fragments and several axehead chips were found from both inside the enclosure and in the excavated area to the north-east.

Unprotected burials on Knockadoon Hill

One Neolithic burial was found on the northern slope and fifteen Neolithic burials were recorded on the excavations of Neolithic houses. The burials were unprotected and in shallow graves. A radiocarbon date from one child burial from Site 10 and associated Class Ia pottery vessel from an adolescent burial at Site C confirmed Early/Middle Neolithic dates for the burials. The remaining burials are dated by association with early Neolithic houses on Knockadoon.

Radiocarbon dating

A total of three Neolithic radiocarbon dates are available from excavations of the Lough Gur/Knockadoon South area (see Table B.30). Two radiocarbon dates from Circle L were from the first phase of the Central House and had large standard deviations. As this site had intensive later activity, these dates are of limited value in dating the site. A third radiocarbon date from a child burial at Site 10 returned a date range of 3641–3372 cal BC.

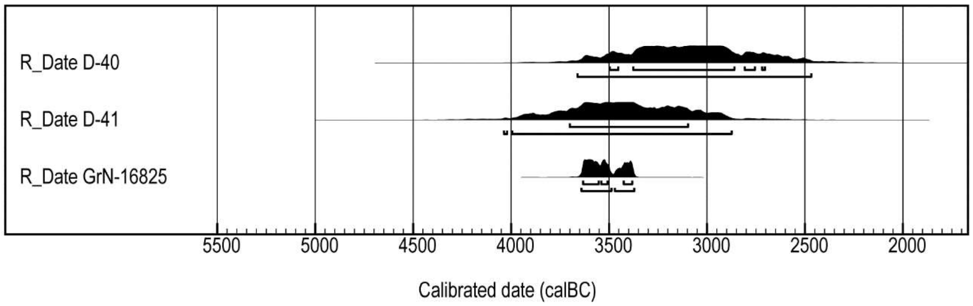

Figure B.73 Calibrated radiocarbon dates from Lough Gur

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
D-40	Circle L	Charcoal	4410 ± 240	3662-2468 cal BC	3497-3454 cal BC (3.4%) 3377-2860 cal BC (59.7%) 2808-2756 cal BC (4.0%) 2719-2704 cal BC (1.1%)
D-41	Circle L	Charcoal	4690 ± 240	4036-4021 cal BC (0.2%) 3995-2874 cal BC (95.2%)	3701-3097 cal BC
GrN-16825	Site 10	Human Bone	4740 ± 60	3641-3488 cal BC (63.3%) 3471-3372 cal BC (32.1%)	3633-3554 cal BC (36.7%) 3540-3509 cal BC (13.7%) 3426-3382 cal BC (17.8%)

Table B.30 Calibrated radiocarbon dates from Lough Gur

(55) Townland: Manor East (site 1)

Barony: Trughanacmy

County: Kerry

Site Type: Pit and post-hole

SMR:

Excavation Licence Number: E4323

ITM: 485911, 613359

National Grid: 865117, 113341

OD: 7-12m

Reference: (Clarke 2012)

The site was identified in advance of road works on the N22 Tralee Bypass/Tralee to Bealagrellagh road scheme and was fully excavated in January and April 2011. Pit and post-hole features were identified in 3 areas of the site.

Area 2

Irregular shaped pit C.968, orientated northeast-southwest, was located approximately 4.80m from the eastern limits of excavation in Area 2. Truncating the centre of this feature was circular stake-hole C.995. The main fill C.996 of the pit contained two fragments of prehistoric pottery. Above this was the upper fill C.969, which contained a single bodysherd of prehistoric pottery.

Area 3

The remains of what appeared to be a possible temporary structure (2) were located close to the southwestern edge of Area 3. This building was sub-rectangular in plan, measuring approximately 5.20m in length (northwest/southeast) by 2.40m in width. It consisted of a single stake-hole, C.158, and seven post-holes, C.144, C.147, C.153, C.182, C.185, C.206 and C.214. Post-hole C.214, located at the eastern corner of the structure, contained two fragments of charred hazelnut shell within its fill C.215; hazel charcoal from this deposit returned an Early Neolithic date range. Post-hole C.169, was identified within the confines of structure 2 and appeared to be an internal support. Situated outside the southern corner of this structure were two stake-holes C.141 and C.142 and a post-hole C.190. These may have functioned as external supports or represented an annex to the structure. Fill C.146 of stake-hole C.142 contained a necksherd and seven fragments of prehistoric pottery. Fill C.189 of post-hole C.190 contained two fragments of charred hazelnut shell. A single bodysherd from a prehistoric pottery was also recovered from this deposit. Located approximately 6.80m to the northeast of structure 2 was post-hole C.166. It was filled by C.167, which contained 34 fragments of charred hazelnut shell and two grains of unidentified cereals. Two fragments of prehistoric pottery were also recovered from this deposit.

Area 5

A single pit, C.729, was located towards the centre of the site in Area 5. Pit C.729 was truncated by later pit C.673. A sample of the alder charcoal from this deposit returned an Early Neolithic date range. No diagnostic remains were recovered from this feature.

Ceramics

The assemblage at Manor East (site 1) consisted of fourteen sherds of pottery from at least seven vessels and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). All pottery was recovered from Areas 2 and 3 with fragments found in fill C.969 of pit C.968 and fill C.970 of stake-hole C.995 of Area 2. Fragments were also recovered from fill C.146 of stake-hole C.142, fill C.167 of post-hole C.166 and fill C.189 of post-hole C.190, all from the possible structure (2) from Area 3.

Archaeobotanical remains

The archaeobotanical remains consisted of a small assemblage of charred hazelnut shell fragments from fills C.167 and C.189 of post-holes C.166 and C.190 of possible structure 2. Also identified were two unidentified charred cereal grains from fill C.167 of post-hole C.166.

Radiocarbon dating

Two Early Neolithic radiocarbon dates were obtained following excavations at Manor East (site 1) (see Table B.31). A date of 4044-3817 cal BC was returned from an oak charcoal fragment taken from the fill C.730 of pit C.729 from Area 5. A fragment of hazel charcoal recovered from the fill C.215 of post-hole C.214 from Area 3 returned a radiocarbon date of 3798-3652 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
Suerc-37321	C.214	Hazel Charcoal	4955 ± 35	3798-3652 cal BC	3774-3695 cal BC
Suerc-37323	C.729	Oak Charcoal	5165 ± 35	4044-3940 cal BC (89.2%) 3857-3817 cal BC (6.2%)	4036-4022 cal BC (12.1%) 3994-3954 cal BC (56.1%)

Table B.31 Calibrated radiocarbon dates from Manor East (site 1)

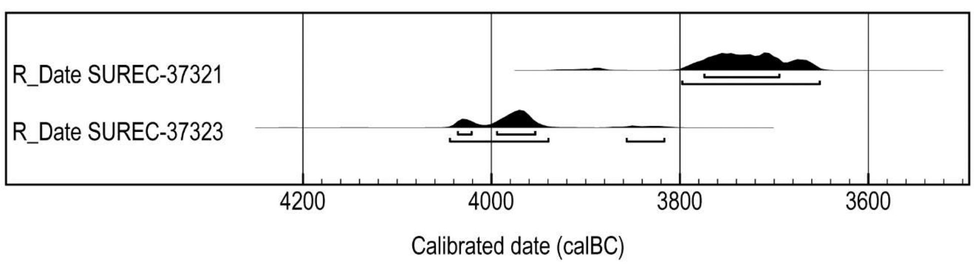

Figure B.74 Calibrated radiocarbon dates from Manor East (site 1)

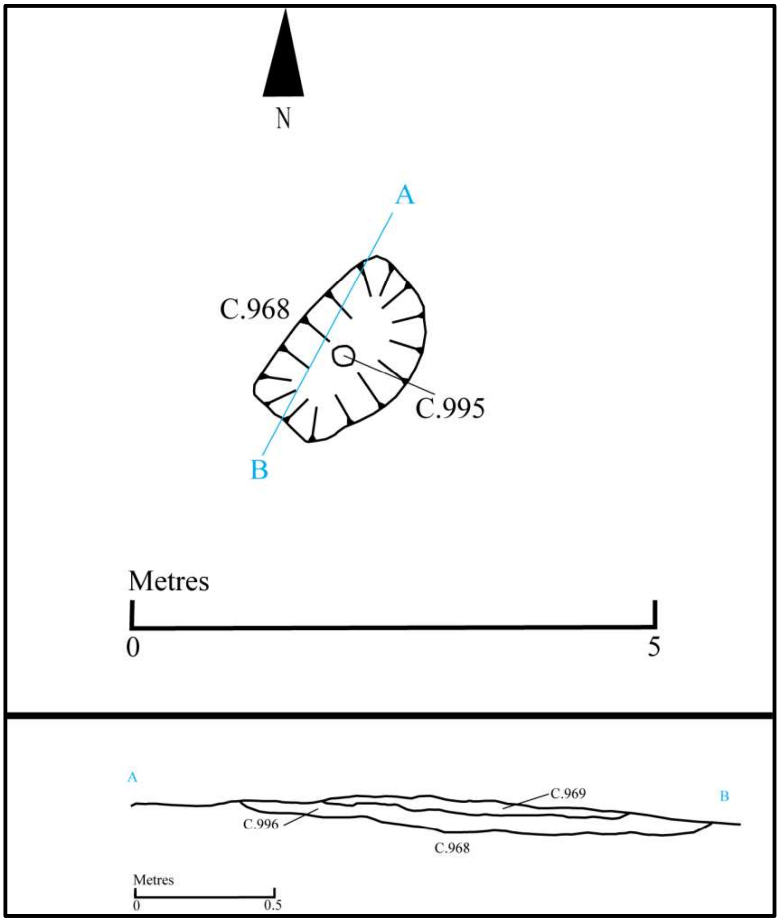

Figure B.75 Early Neolithic feature from Area 2, Manor East (site 1)

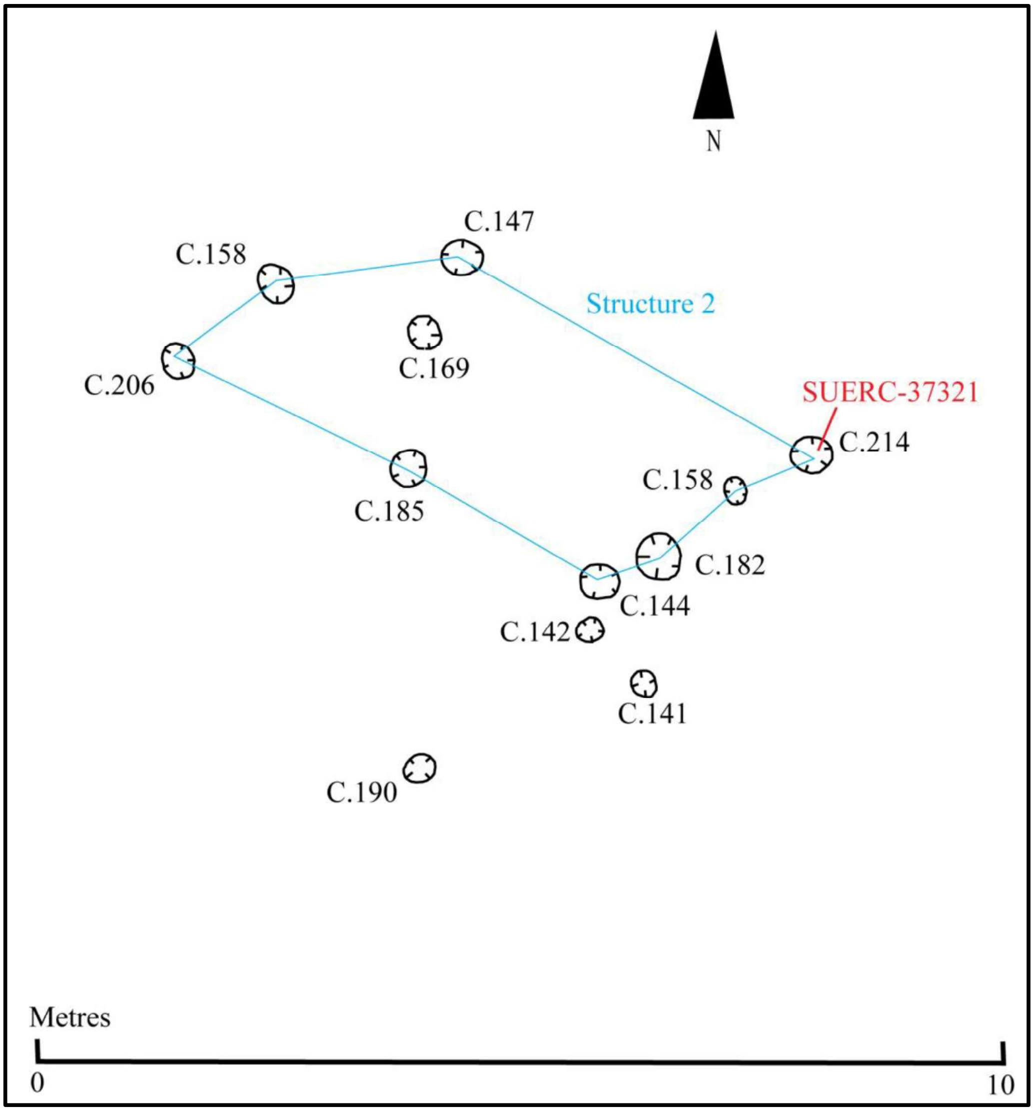

Figure B.76 Early Neolithic features from Area 3, Manor East (site 1)

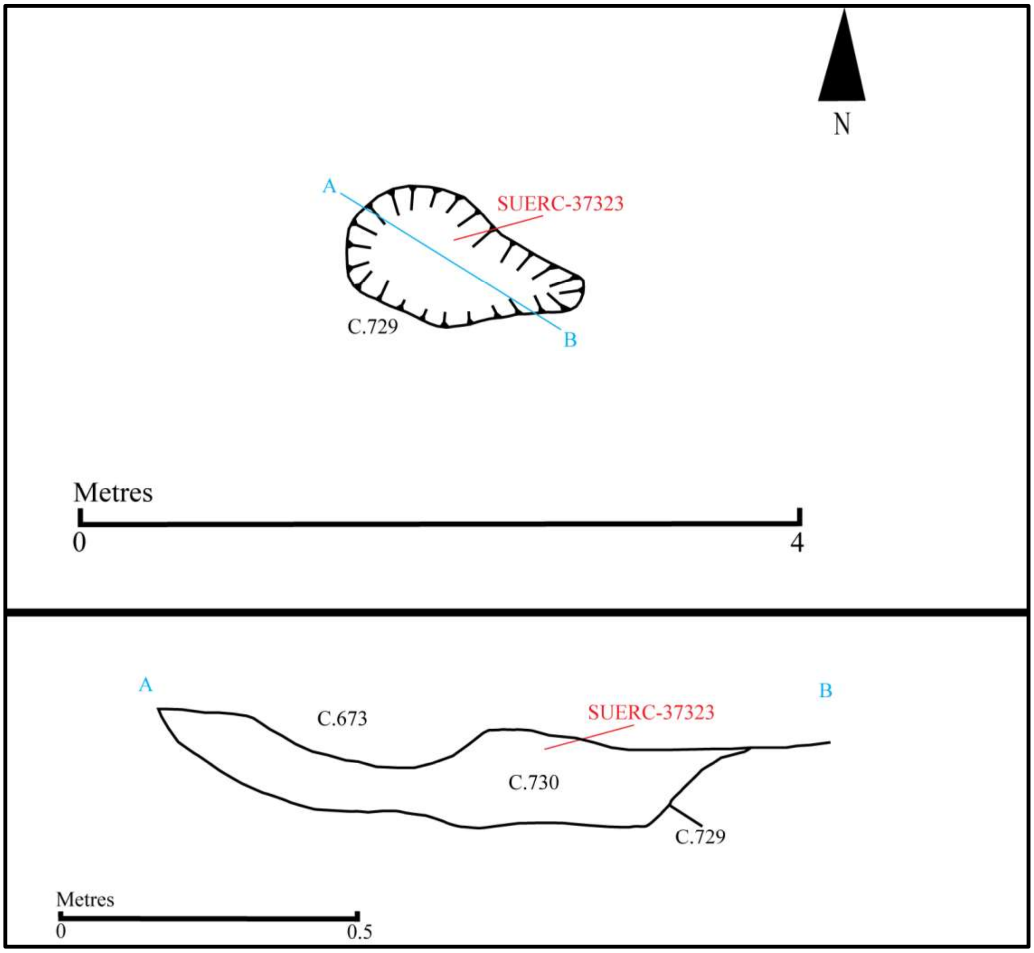

Figure B.77 Early Neolithic feature from Area 5, Manor East (site 1)

(56) Townland: Manor West

Barony: Trughanacmy

County: Kerry

Site Type: Pits & stake-holes

SMR:

Excavation Licence Number: 00E0069

ITM: 485309, 613556

National Grid: 85333, 113502

OD:

Reference: (Dunne 2002; 2005, 58-59; Connolly 2008, vol. 2, 161-165)

The site was identified in advance of the development of a retail park and was fully excavated in the summer and autumn of 2000. Nine areas of activity were identified with Early Neolithic activity confined to Area 2.

Area 2

Area 2 lay directly west of Area 1, separated from the latter by a long, narrow section of unstripped topsoil. This area was a maximum of 65m long by *c.*8m wide. The most notable feature in Area 2 was part of a large ditch, 12m of which was visible (width 3.5m, depth 0.81m), and it was aligned roughly south-south-west/north-north-east. Several stake-holes were cut into the western side of the ditch near its upper break of slope. One section of this ditch cuts through a post-pipe, suggesting that there may have been a palisade fence within it. A number of possible stake-holes were recorded in the area around the terminal of this ditch, and a quantity of worked flint and chert was recovered from its fills. Most of these lithics were recovered in the terminal area of the ditch, adjacent to what may have been an entranceway. Several pits farther north in this area also yielded lithic artefacts and prehistoric pottery identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8).

Radiocarbon dating

A sample of the charcoal from one of these pits returned an Early Neolithic date range of 3951-3713 cal BC (see Table B.32).

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
QUB-7654	Unknown	Charcoal	5036±40	3951-3758 cal BC (88.5%) 3744-3713 cal BC (6.9%)	3941-3857 cal BC (46.5%) 3818-3776 cal BC (21.7%)

Table B.32 Calibrated radiocarbon dates from Manor West

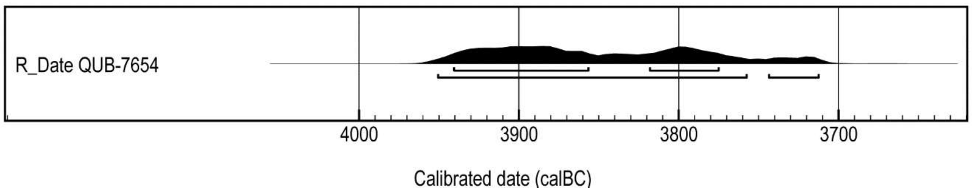

Figure B.78 Calibrated radiocarbon dates from Manor West

(57) Townland: Marlfield

Barony: Iffa and Offa East

County: Tipperary

Site Type: Neolithic Rectangular House

SMR: TS082-104----

Excavation Licence Number:

ITM: 616361, 622076

National Grid: 216414, 122024

OD:

Reference: (Lennon 2007; Looney 2011, 104, 206; Farrelly 2012)

The site was uncovered during archaeological testing in advance of a proposed development, however no final report has as yet been produced. A Neolithic house, measuring *c.*8.5m east-northeast/west-southwest and *c.*8m north-northeast/west-southwest, was delimited by a foundation trench within which were set a series of stake-holes of squared upright posts. Each corner was defined by a large post-hole. Two other post-holes were associated with the house, one inside the eastern edge of the foundation trench and another outside the house. A possible internal slot trench was uncovered *c.*0.2m south of the foundation trench.

Ceramics

157 fragments of prehistoric pottery from at least 11 vessels were recovered from the site and were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). No details of the precise location for the discovery of this material is available.

Lithics

The lithic assemblage included flint and chert waste flakes, cores and debitage. No details of the precise location for the discovery of this material is available.

Archaeobotanical remains

The archaeobotanical assemblage consisted of grains of emmer wheat and a charred hazelnut shell. No details of the precise location for the discovery of this material is available.

Radiocarbon dating

At least one radiocarbon date was initially obtained following excavation at Marlfield (see Table B.33). Charred hazelnut shells returned date ranges of 3634-3377 cal BC (Farrelly 2012) or alternatively 3629-3582 cal BC (Looney 2011, 104). As the full the full details of the radiocarbon date are unknown it cannot be used to correctly establish a chronology for Marlfield. Two further radiocarbon dates were obtained for Marlfield as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Wheat grains from fill, C.4 of the slot trench returned date ranges of 3650-3522 cal BC and 3636-3381 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
UBA-14792	C.4	Wheat Grain	4800 ± 31	3650-3621 cal BC (20.5%) 3606-3522 cal BC (74.9%)	3640-3630 cal BC (12.3%) 3580-3533 cal BC (55.9%)
UBA-14793	C.4	Wheat Grain	4747 ± 32	3636-3506 cal BC (79.5%) 3427-3381 cal BC (15.9%)	3632-3558 cal BC (54.0%) 3538-3518 cal BC (14.2%)

Table B.33 Calibrated radiocarbon dates from Marlfield

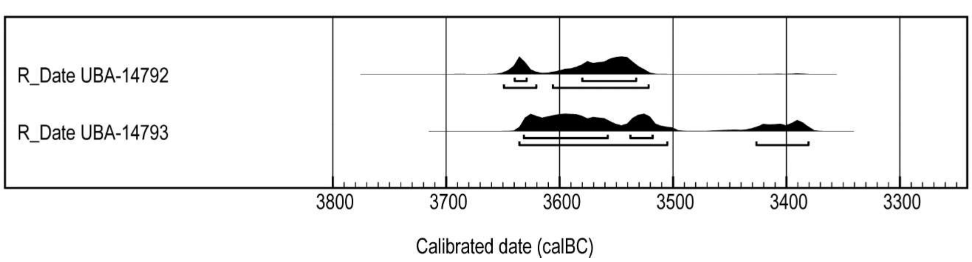

Figure B.79 Calibrated radiocarbon dates from Marlfield

(58) Townland: Monadreela (site 7)
Barony: Middlethird
County: Tipperary
Site Type: Pit
SMR:
Excavation Licence Number: 03E0300
ITM: 609601, 641954
National Grid: 209632, 141924
OD: 148-150m
Reference: (O'Brien 2014c)

The site was identified in advance of roadworks on the of the N8 Cashel Bypass & N74 Link Road and was fully excavated in March 2003. A possible Neolithic pit was located at the western edge of the road-take. Pit C.126 was filled with two deposits, C.127 and C.32. The basal deposit C.127 only survived at one side of the cut being only 0.09m deep it was similar to the natural deposits and may represent slippage from the original pit-cut. It was sealed by fill C.32. During excavation of the pit this deposit, C.32, was found to contain nine sherds and one crumb of prehistoric pottery. In addition, a shale bead/pendant was also recovered from the same fill. However, oak charcoal from fill C.32 returned a Bronze Age radiocarbon dated to 2462-2235 BC (*UBA-13714,* 3867±22). A large, creamy-beige flint flake was recovered from the topsoil adjacent to ring-ditch C.02, *c.*22m north of pit C.26. Post-hole C.82, found within the confines of the ring-ditch produced an Early Neolithic date range.

Ceramics

The ceramic assemblage consisted of 10 fragments of prehistoric pottery from at least 1 vessel which was identified as an Early Neolithic Carinated Bowl, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). All fragments were recovered from fill C.32 of pit C.126.

Lithics

The lithic assemblage included a shale bead/pendant from fill C.32 of pit C.126 and a flint flake recovered during topsoil stripping. Analysis of the flint confirmed it was likely Neolithic in date.

Radiocarbon dating

A single Early Neolithic radiocarbon date was returned obtained following excavations at Monadreela (site 7) (see Table B.34). Oak charcoal from post-hole C.82 returned a radiocarbon date range of 3956-3771 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-13711	C.82	Oak Charcoal	5050 ± 32	3956-3771 cal BC	3941-3856 cal BC (53.5%) 3818-3794 cal BC (14.7%)

Table B.34 Calibrated radiocarbon dates from Monadreela (site 7)

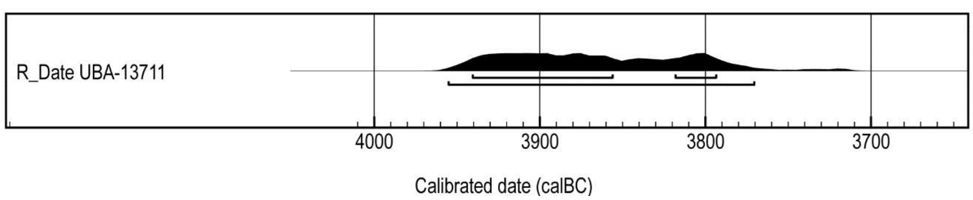

Figure B.80 Calibrated radiocarbon dates from Monadreela (site 7)

(59) Townland: Monadreela (site 9)

Barony: Middlethird

County: Tipperary

Site Type: Possible structure

SMR:

Excavation Licence Number: 03E0345

ITM: 609598, 641885

National Grid: 209622, 141817

OD: 150m

Reference: (O'Brien 2014d)

The site was identified in advance of roadworks on the of the N8 Cashel Bypass & N74 Link Road and was fully excavated between March and May 2003. The remains of a small circular structure were recorded to the south-west of the site. The structure measured *c.*1.8m in diameter and was comprised of pair of curvilinear slot trenches, C.97 and C.104, and post-hole C.98. Wall slot C.104 defined the south-western wall of the structure and measured *c.*1.2m in length. A flint blade or flake was recovered from its fill, C.91. The north-west wall was demarcated by wall slot C.97 and measured *c.*1.6m in length. No finds were recovered from the fill, C.45. Post-hole C.98 was situated to the northern extent of the structure, *c.*0.2m north-west of wall slot C.97 and *c.*1.3m north-east of wall slot C.104. The fill C.46 of post-hole C.98 contained sherds of prehistoric pottery. An Early Neolithic radiocarbon date range was returned from charcoal recovered from fill C.46.

Ceramics

The ceramic assemblage consisted of 9 fragments of prehistoric pottery from at least 2 vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). All fragments were recovered from fill C.46 of post-hole C.98.

Lithics

The lithic assemblage consisted of a single fractured distal end of a large blue-grey flint blade or flake of likely Neolithic date.

Radiocarbon dating

A single Early Neolithic radiocarbon date was returned obtained following excavations at Monadreela (site 9) (see Table B.35). Holly charcoal from fill C.46 of post-hole C.98 returned a radiocarbon date range of 3661-3524 cal BC

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-13720	C.98	Holly Charcoal	4822 ± 32	3661-3623 cal BC (36.4%) 3602-3524 cal BC (59.0%)	3650-3631 cal BC (29.1%) 3578-3574 cal BC (3.1%) 3565-3536 cal BC (36.1%)

Table B.35 Calibrated radiocarbon dates from Monadreela (site 9)

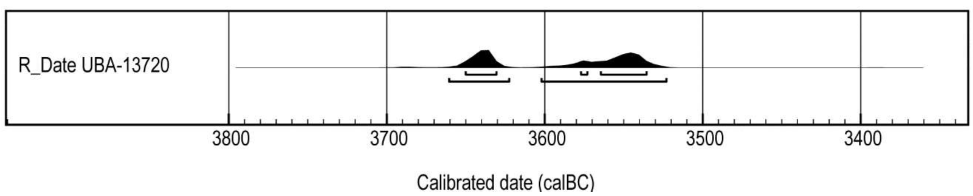

Figure B.81 Calibrated radiocarbon dates from Monadreela (site 9)

(60) Townland: Monadreela (site 11)

Barony: Middlethird

County: Tipperary

Site Type: Pits

SMR:

Excavation Licence Number: 03E0346

ITM: 609612, 641817

National Grid: 209654, 141772

OD: 150m

Reference: (O'Brien 2014e)

The site was identified in advance of roadworks on the of the N8 Cashel Bypass & N74 Link Road and was fully excavated in May 2003. Pit C.23 was recorded towards the centre of the site and contained five fills C.24, C.25, C.26, C.27 and C.28. A single possible find of struck flint was identified from fill C.26, while an Early Neolithic radiocarbon date range was returned from charcoal recovered from fill C.27.

Lithics

The lithic assemblage consisted of a single piece possible struck flint.

Radiocarbon dating

A single Early Neolithic radiocarbon date was returned obtained following excavations at Monadreela (site 11) (see Table B.36). Oak charcoal from fill C.27 of pit C.23 returned a radiocarbon date range of 3661-3524 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2Ϭ) 95.4% Probability	Calibrated Age (1Ϭ) 68.2% Probability
UBA-13730	Fill C.27 of pit C.23	Oak Charcoal	5049 ± 22	3946-3788 cal BC	3937-3863 cal BC (56.8%) 3812-3797 cal BC (11.4%)

Table B.36 Calibrated radiocarbon dates from Monadreela (site 11)

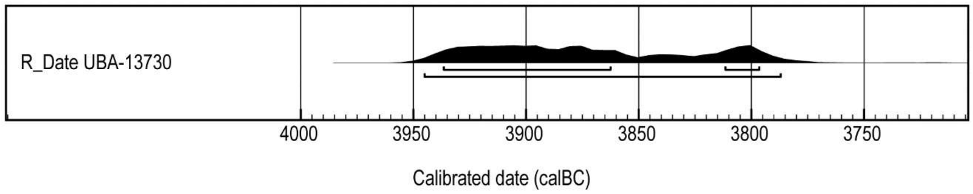

Figure B.82 Calibrated radiocarbon dates from Monadreela (site 11)

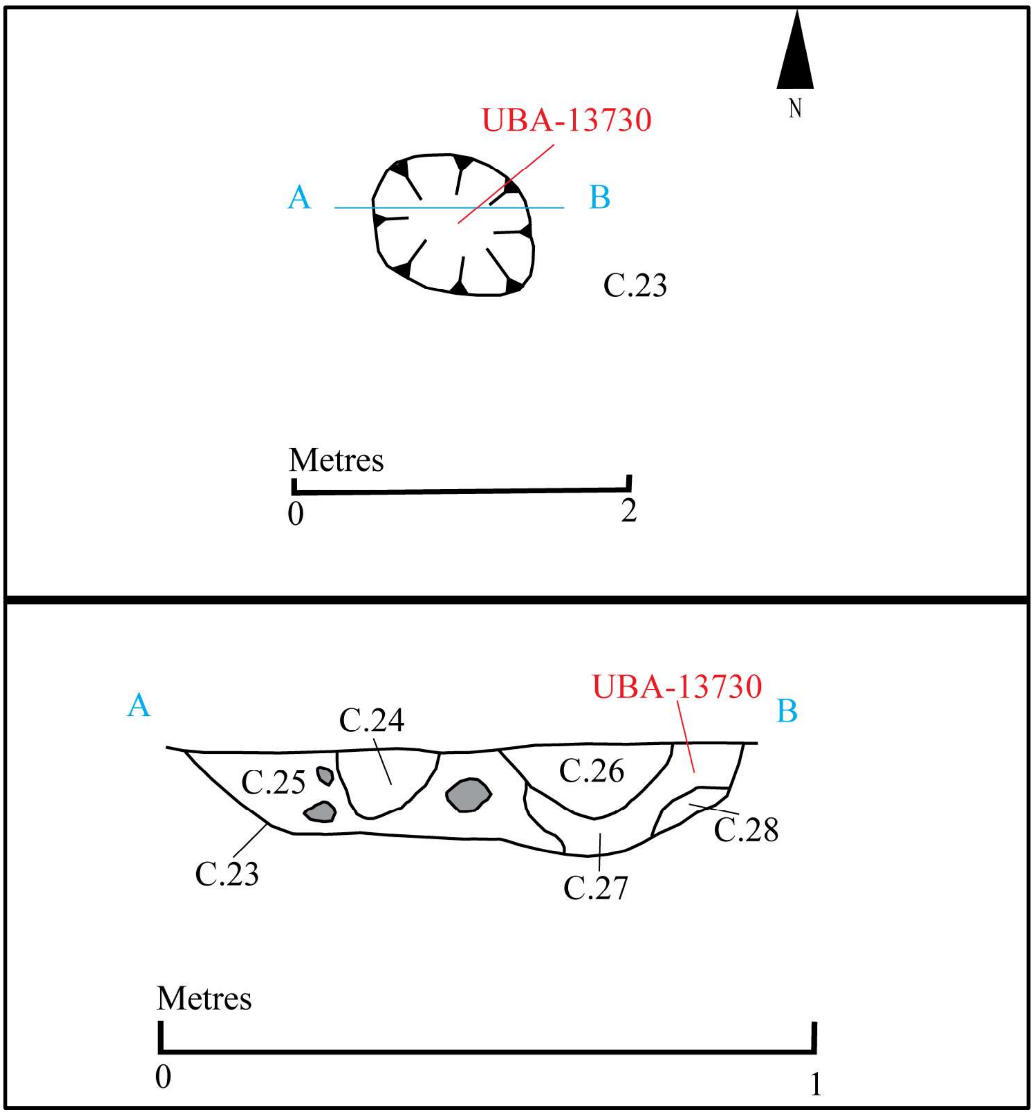

Figure B.83 Neolithic features from Monadreela (site 11)

(61) Townland: Newmarket

Barony: Knocktopher

County: Kilkenny

Site Type: Portal tomb

SMR: KK031-031----

Excavation Licence Number: N/A

ITM: 650364, 635276

National Grid: 250424, 135227

OD: 300-400m

Reference: (Ó Nualláin 1983, 97)

The site is situated on a level area of a hill at the head of a valley of a tributary of the River Nore, which lies *c.*8.5km to the north-east. The remains of this portal tomb consist of a ruined chamber, two portal stones and a roof-stone. The roof-stone measures *c.*2.55m by *c.*2.25m with a maximum thickness of *c.*0.45m. The two portal-stones stand at a height of *c.*2.1m and *c.*1.65m. The site has not been excavated.

(62) Townland: Newrath (site 35)

Barony: Kilculliheen

County: Kilkenny

Site Type: Pits

SMR:

Excavation Licence Number: 04E0319

ITM: 659425, 614155

National Grid: 259487, 114102

OD:

Reference: (Wilkins 2006; Hughes *et al.* 2011)

The site was identified in advance of roadworks on the N25 Waterford bypass and was fully excavated between March and April 2004. Three ritual pit features, including a Neolithic axe hoard, were identified as the first phase of activity at Site 35. One of these features C.46 had been partially truncated by two later features but still retained its integrity. It was filled by a primary deposit C.47 and a secondary deposit C.48 was also recorded towards the top of the feature, most likely to have been redeposited natural. Fill C.47 contained lithics, 13 pottery fragments. The location of artefacts midway through the fill rather than against the sides of the feature, in addition to the capping of redeposited natural suggested that this was deposited as a single action, perhaps with sweepings of a symbolic fire. An Early Neolithic radiocarbon date was obtained from a charred grain recovered from deposit C.47.

Two further pit features were identified adjacent to C.46 and were also characterised as ritual hoard pits. Pit C.28 was filled by two separate deposits and had been truncated by two later pits. It was filled by a primary fill C.66 which contained 28 sherds of prehistoric pottery and a secondary fill C.75 containing one flint scraper and 36 sherds prehistoric pottery. A secondary recut C.78 truncated fill C.66 on its western side and was filled by C.29. A thin, flat shale bead with a flat perforation and 1 fragment of prehistoric pottery were recovered from this context. The final ritual hoard pit in this phase was C.93, which contained two fills C.97 and C.94. The primary fill C.94 contained 57 sherds of prehistoric pottery. Feature C.91 was a circular post-hole filled by C.92, which contained 1 sherd of prehistoric pottery. Several other pits and post-holes were located in this central part of the site. No finds were recovered from these features and they did not appear to maintain any structural pattern or integrity. An Early Neolithic radiocarbon date was returned from a hazelnut shell recovered from post-hole C.85.

Ceramics

The ceramic assemblage consisted of 145 fragments of prehistoric pottery from at least 18 vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). All fragments were recovered from fills C.66 and C.75 of pit C.28, truncated fill C.29, fill C.47 of pit C.46 and fill C.94 of pit C.93.

Lithics

The lithic assemblage consisted of numerous axe heads, a leaf shaped arrowhead, a large stone core, a struck flint flake from fills C.47 of pit C.46 and a shale bead from fill C.29. All were of likely Neolithic date.

Archaeobotanical remains

Small quantities of charred cereals, in particular emmer wheat, and hazelnut shell fragments were found in two Early Neolithic contexts, fill C.66 of pit C.28 and fills C.47 and C.48 of pit C.46.

Radiocarbon dating

Two radiocarbon dates were initially obtained following excavation at Newrath (site 35) (see Table B.37). Charred wheat grains from fill C.47 of pit C46 and a hazelnut shell from C.82 returned date ranges of 3696-3522 cal BC and 3694-3521 cal BC respectively. Two additional radiocarbon dates were obtained for Newrath (site 35) as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Cereal grains from two fills, C.66 of pit C.28 and C.48 of pit C.46 returned date ranges of 3636-3384 cal BC and 3650-3526 cal BC respectively.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-14798	Fill C.48 of pit C.46	Emmer Wheat Grain	4809±26	3650-3626 cal BC (25.2%) 3597-3526 cal BC (70.2%)	3643-3631 cal BC (18.7%) 3578-3574 cal BC (4.0%) 3565-3536 cal BC (45.5%)
UBA-14799	Fill C.28 of pit C.29	Emmer Wheat Grain	4754±27	3636-3514 cal BC (88.0%) 3422-3404 cal BC (3.0%) 3399-3384 cal BC (4.4%)	3632-3619 cal BC (10.5%) 3610-3558 cal BC (43.6%) 3538-3521 cal BC (14.1%)
UB-6639	Fill C.47 of pit C.46	Emmer Wheat Grain	4827 ± 39	3696-3622 cal BC (42.2%) 3606-3522 cal BC (53.2%)	3654-3630 cal BC (30.0%) 3578-3535 cal BC (38.2%)
UB-6640	C.85	Hazelnut Shell	4821 ± 38	3694-3678 cal BC (2.3%) 3666-3618 cal BC (33.4%) 3610-3521 cal BC (59.7%)	3651-3630 cal BC (24.6%) 3579-3534 cal BC (43.6%)

Table B.37 Calibrated radiocarbon dates from Newrath (site 35)

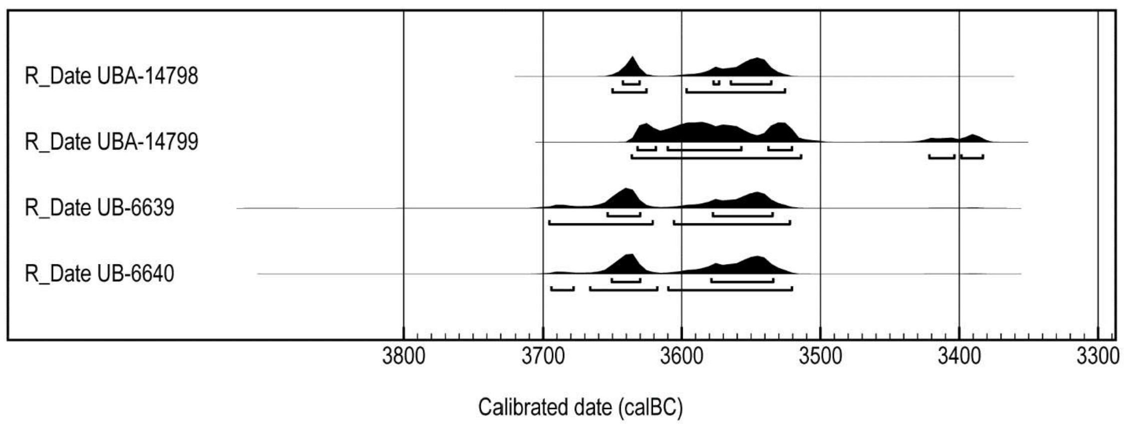

Figure B.84 Calibrated radiocarbon dates from Newrath (site 35)

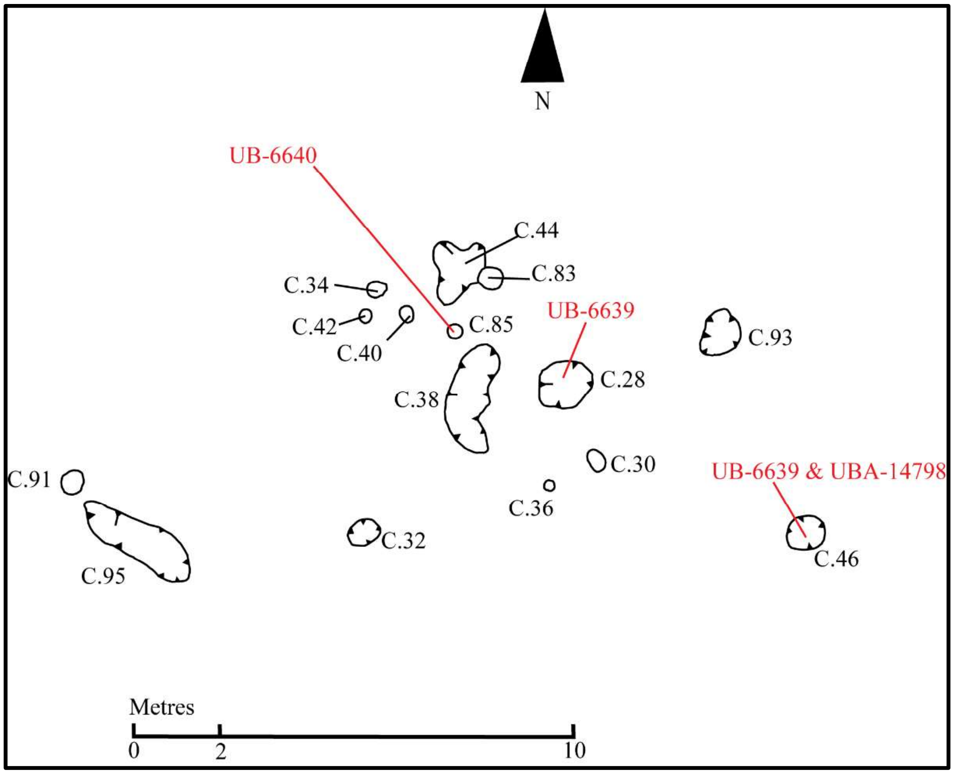

Figure B.85 Early Neolithic features from Newrath (site 35)

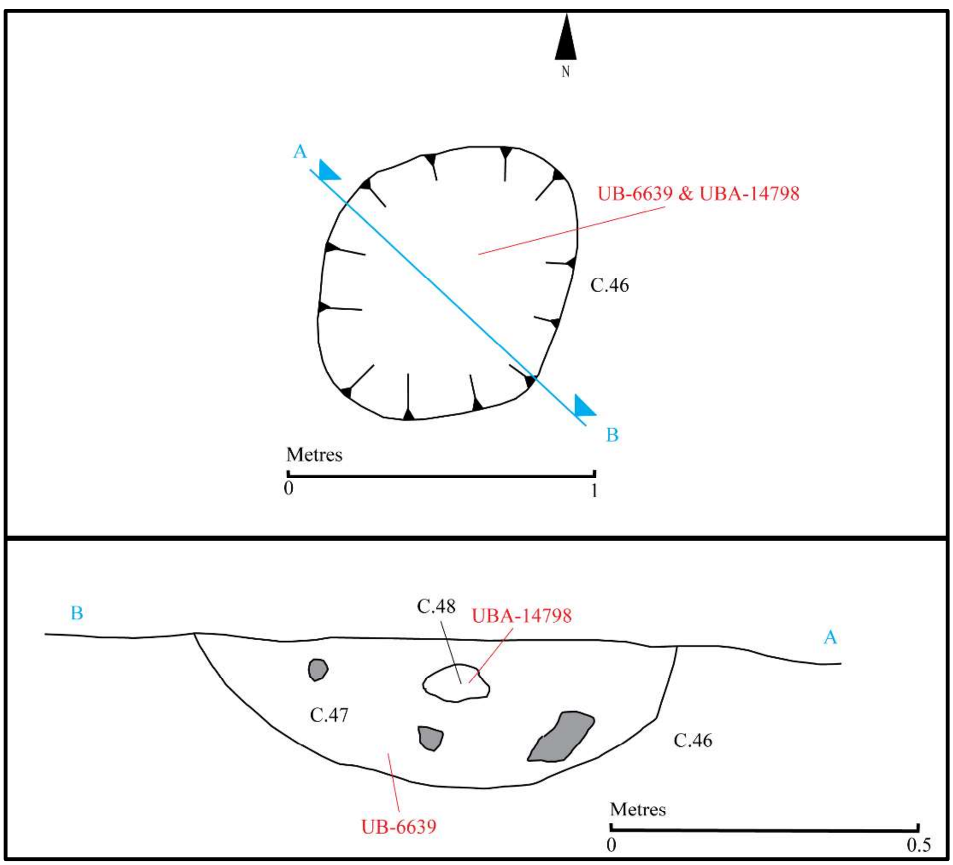

Figure B.86 Early Neolithic ritual pit C.46 from Newrath (site 35)

(63) Townland: Newrath (site 37)

Barony: Kilculliheen

County: Kilkenny

Site Type: Neolithic Rectangular House

SMR:

Excavation Licence Number: 04E0288

ITM: 659425, 614155

National Grid: 259487, 114102

OD:

Reference: (Wren 2006c; Wren and Price 2011)

The site was identified in advance of roadworks on the N25 Waterford bypass and was fully excavated between May and July 2004. The foundations of a rectangular structure, orientated northeast to southwest, were uncovered in the centre of the site. These consisted of three slot trenches, one to the northwest, another to the northeast and a third to the southeast. There was no obvious wall foundation along the southwest side of the building. The structure had maximum external dimensions of *c*.7m northeast/southwest and *c*.5.20m northwest/southeast.

North-eastern wall

The north-eastern wall was defined by slot trench C.29. A corner post-pit C.33, at its northern end and corner stake-hole C.48, at its eastern end, demarcated the extent of the north-eastern wall.

North-western wall

The north-western wall was defined by slot trench C.17 and was filled by C.20, which contained a leaf-shaped arrowhead, some burnt hazelnut shells, charred emmer wheat grains and a tuber. The tuber may have resulted from root intrusion, possibly dating to the late eighteenth century when the area was used for tillage.

South-eastern wall

The south-eastern wall was defined by slot trench C.30 and consisted of two sections either side of the entrance.

South-western wall

There was very little surviving evidence for walling at the southwestern end of the building. At the southern corner a return on the south-eastern slot trench, may have formed the foundation for 0.80m of walling. A pit C.38 just inside the line of the slot trench may have also had a structural role at this end of the building.

Internal Layout

A series of six small pits, which may have originally held structural uprights, were recorded inside the building. At least two of these, C.18 and C.74 were centrally located and in line with the possible jamb post beside the eastern entrance. Fill C.19 of pit C.18 (19) contained a Neolithic plano-convex knife and an end of blade scraper, burnt hazelnut shells were also recovered from the fill of this pit. Fill C.69 of pit C.74 contained a worked flint nodule. These two features may have formed the foundation for an internal wall aligned northwest/southeast.

External Features

Two large pits, C.35 and C.37, were located directly outside the western corner of the structure. Both had largely sterile fills and no evidence for in situ burning. A third pit C.14 was found 19m northwest of the rectangular structure. Pit C.14 contained two fills C.53 C.52, with a fragment of prehistoric pottery recovered from C.52.

Ceramics

The ceramic assemblage consisted of 2 fragments of prehistoric pottery from at least 1 vessel which was identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). Both fragments were recovered from fill C.52 of pit C.14 and a residual find from fill C.161 of the Early Bronze Age ring-ditch C.181.

Archaeobotanical remains

Small quantities of charred cereals, in particular emmer wheat and naked barley, were found in fill C.52 of pit C.14. The stone from a blackthorn/sloe and charred hazelnut shells were also recovered from this context. Hazelnut shells were also identified in fill C.20 of foundation trench C.17.

Radiocarbon dating

A single radiocarbon date was obtained from charred hazelnut shells from fill C.20 of foundation trench C.17 and returned a Late Mesolithic date range of 4492-4349 cal BC (see Table B.38). This date is considerably earlier than other dated examples of Early Neolithic rectangular houses and is therefore likely to be from residual material.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-6642	C.17	Hazelnut shell	5587±40	4492-4349 cal BC	4453-4369 cal BC

Table B.38 Calibrated radiocarbon dates from Newrath (site 37)

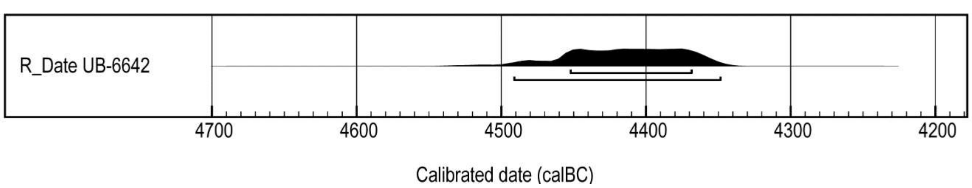

Figure B.87 Calibrated radiocarbon dates from Newrath (site 37)

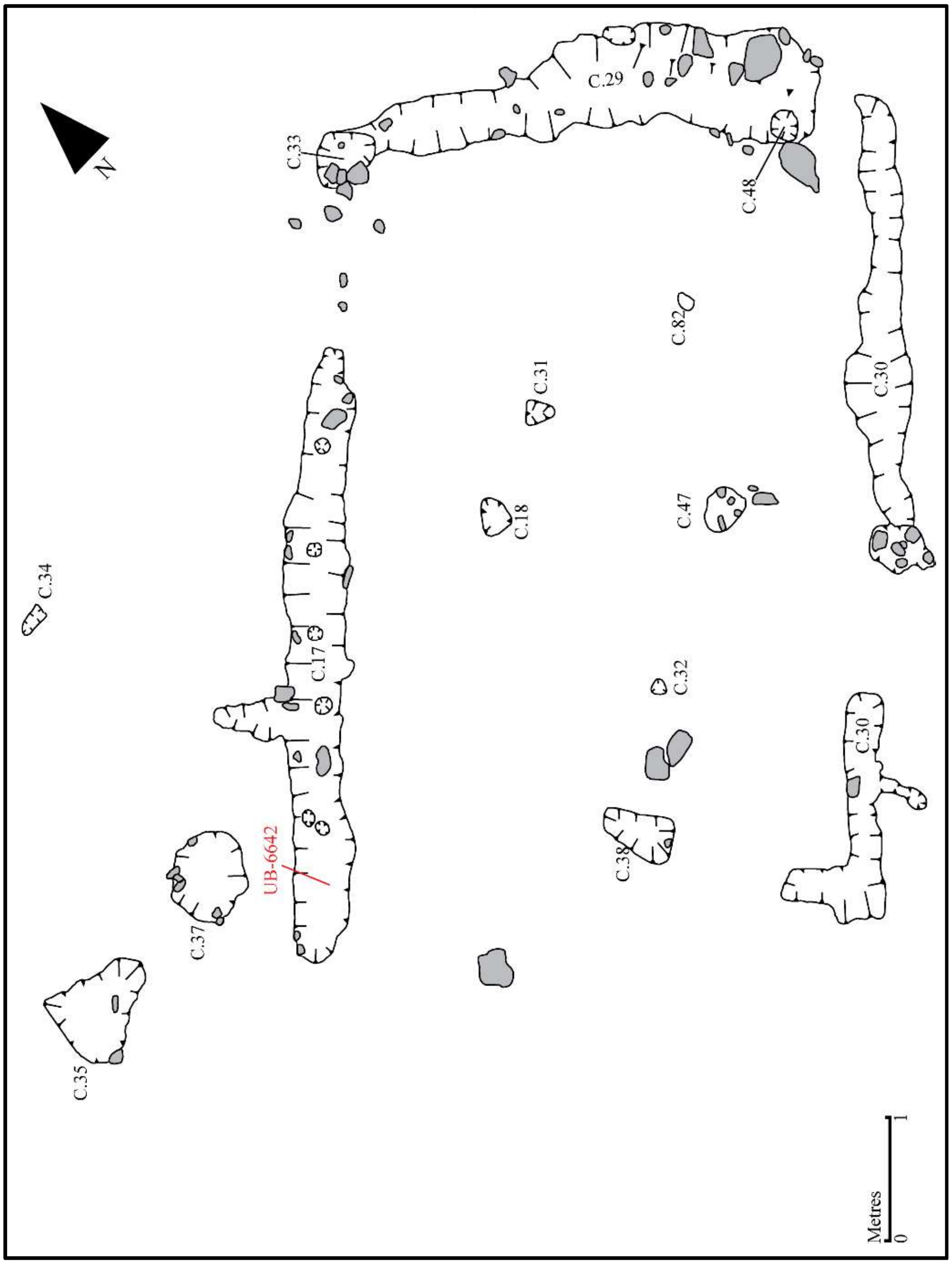

Figure B.88 Neolithic features from Newrath (site 37)

(64) Townland: Newtown (Carrigdirty Rock site 5)

Barony: Pubblebrien

County: Limerick

Site Type: Neolithic wetland occupation site

SMR: N/A

Excavation Licence Number: N/A

ITM: 546889, 657472

National Grid: 147814, 157690

OD: 1.5m

Reference: (O'Sullivan 2001, 73-86; Woodman 2016, 16)

The site at Carrigdirty Rock (site 5) was a scatter a scatter of lithics, organic artefacts, human and animal bone located on a narrow foreshore on the south bank of the Shannon estuary. The site was recorded during eight repeat visits between 1994 and 1997. Two large woven basket fragments were found embedded in reedy minerogenic clays at the extreme western end of the site while a further, smaller fragment was recovered from the eastern end of the site and is likely from the same basket. The basket was constructed of thin alder shoots, aged less than one-year old.

Lithics

The lithic assemblage consisted of a micaceous slate stone axe was recovered as an unstratified find in 1998, four pebbles of limestone, quartz, green dolerite and granite. The limestone pebble may have been used as a hammer stone. Two small chert flakes were recovered stratified the clays beside the basket findspot.

Archaeobotanical remains

Hazelnut fragments were recovered in the clays scattered across the site. A single piece of worked hazel Roundwood, with visible stone axe worked marks was recovered from the clays. Several fragments of split and charred oak were recovered lying horizontally in the clays.

Archaeozoological remains

A proximal portion of a metacarpus and two vertebrae from a juvenile bovine at the west end of the site. Three bones of an adult swan, likely a mute swan, were also recovered in the reedy clays near the fish basket.

Human Remains

A large fragment of a human skull, broken from the frontal-parietal part of the cranium was recovered from an unstratified context at the eastern end of the site. The bone probably derived from an individual aged between 25-35 years old. A right clavicle was also found on the clays.

Radiocarbon dating

Six Early Neolithic radiocarbon dates were returned from Carrigdirty Rock (site 3) (see Table B.39). Two samples of alder shoots from the fragments of basket returned identical date ranges of 3705-3384 cal BC and a fragment of cattle bone returned a date range of 3646-3382 cal BC. Three radiocarbon dates were obtained from the fragments of human bone returning date range of 3634-3370 cal BC, 3646-3382 cal BC and 3644-3381 cal BC.

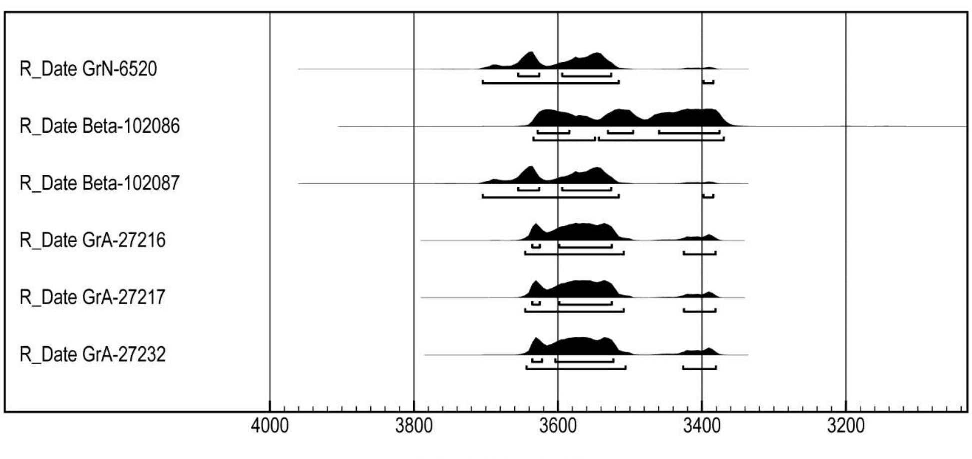

Figure B.89 Calibrated dates from Carrigdirty Rock (site 3)

These six dates were plotted using OxCal 4.2.4.4 (Bronk Ramsey 1995; 1998; 2001; 2009a) to propose refined dates for the start and end of the activity at Carrigdirty Rock (site 5). Bayesian modelling returned a date range of *3690-3530 cal BC (95% probability), 3650-3550 cal BC (68% probability)* for the start of activity at Carrigdirty Rock (site 5), and a date range of *3640-3530 cal BC (95% probability), 3580-3510 cal BC (68% probability)* for the end of activity ($A_{overall}$=127.2).

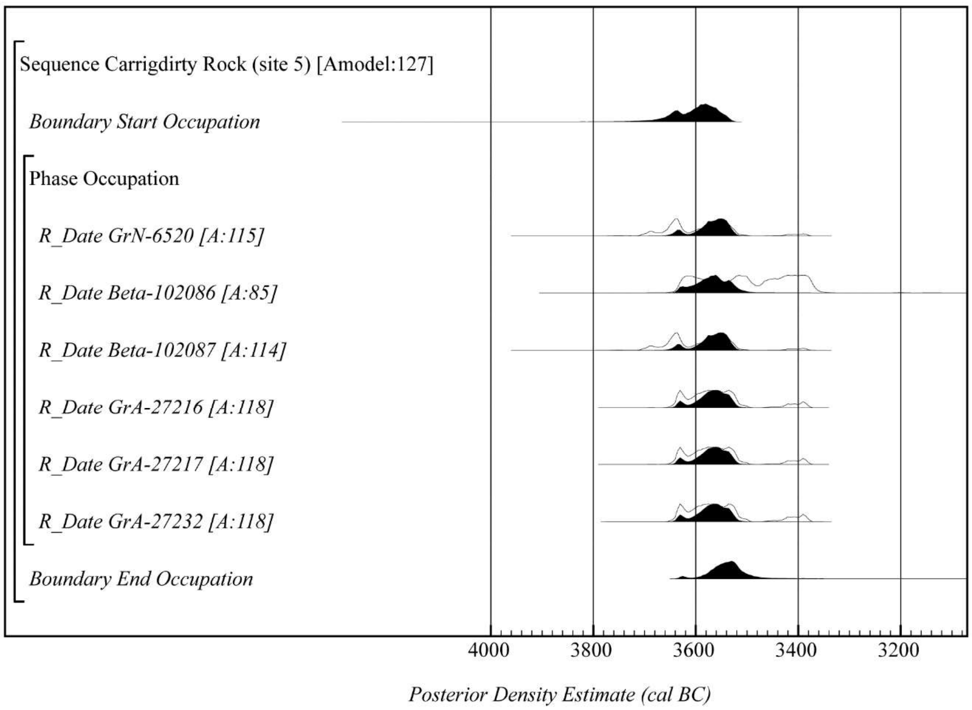

Figure B.90 Bayesian model for occupation at Carrigdirty Rock (site 5)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
GrN-6520	Basket fragment	Waterlogged alder shoots	4820±50	3705-3516 cal BC (94.0%) 3398-3384 cal BC (1.4%)	3656-3626 cal BC (22.0%) 3594-3526 cal BC (46.2%)
Beta-102086	Human skull	Frontal-parietal bone	4710±60	3634-3549 cal BC (29.9%) 3544-3370 cal BC (65.5%)	3628-3584 cal BC (17.9%) 3531-3496 cal BC (14.8%) 3460-3376 cal BC (35.5%)
Beta-102087	Basket fragment	Waterlogged alder shoots	4820±50	3705-3516 cal BC (94.0%) 3398-3384 cal BC (1.4%)	3656-3626 cal BC (22.0%) 3594-3526 cal BC (46.2%)
GrA-27216		Cattle bone	4775±40	3646-3509 cal BC (87.1%) 3426-3382 cal BC (8.3%)	3636-3626 cal BC (8.2%) 3599-3526 cal BC (60.0%)
GrA-27217		Human Clavicle	4775±40	3646-3509 cal BC (87.1%) 3426-3382 cal BC (8.3%)	3636-3626 cal BC (8.2%) 3599-3526 cal BC (60.0%)
GrA-27232		Human Skull fragment	4770±40	3644-3507 cal BC (85.5%) 3427-3381 cal BC (9.9%)	3636-3623 cal BC (9.2%) 3604- 3524 cal BC (59.0%)

Table B.39 Calibrated dates from Carrigdirty Rock (site 3)

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 127.2 Aoverall 127.2				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Carrigdirty Rock (site 5)																	
Boundary Start Occupation							-3646	-3551	68.2	-3683	-3532	95.4					97.9
Phase Occupation																	
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3585	-3534	68.2	-3647	-3522	95.4		114.5			99.5
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3597	-3529	68.2	-3637	-3512	95.4		84.5			99.5
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3585	-3534	68.2	-3648	-3522	95.4		114.4			99.5
R_Date GrA-27216	-3636	-3526	68.2	-3646	-3382	95.4	-3588	-3533	68.2	-3638	-3522	95.4		117.6			99.6
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3588	-3533	68.2	-3638	-3522	95.4		117.6			99.5
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3590	-3532	68.2	-3638	-3522	95.4		117.7			99.6
Boundary End Occupation							-3572	-3512	68.2	-3634	-3464	95.4					97.4

Table B.40 Bayesian model for occupation at Carrigdirty Rock (site 5)

(65) Townland: Owning

Barony: Iverk

County: Kilkenny

Site Type: Portal Tomb

SMR: KK035-053----

Excavation Licence Number: N/A

ITM: 644885, 626772

National Grid: 244944, 126721

OD: 100-200m

Reference: (Borlase 1897, 408; Ó Nualláin 1983, 97)

The site is situated in arable land in a narrow river valley above the River Suir *c*.6km to the south. A small ruined chamber facing south and a roof-stone measuring *c*.2.9m by *c*.2.5m with a maximum thickness of *c*.0.5m, is all that remains. The site has not been excavated.

(66) Townland: Pepperhill

Barony: Orrery and Kilmore

County: Cork

Site Type: Neolithic Rectangular House

SMR: CO016-226001

Excavation Licence Number: E374

ITM: 552547, 608236

National Grid: 152586, 108181

OD:

Reference: (Gowen 1988, 44-51)

A probable but severely truncated rectangular structure was excavated at Pepperhill, County Cork in advance of gas pipeline construction. Four post-holes (C.2, C.6, C.7 & C.16), two shallow pits/hollows (C.13 & C.14) and a linear trench (C.3) were identified during excavation. No additional features were excavated but the site of area of excavation was confined to the eastern area of the site due to a cattle access point. The linear trench had a total length of *c*.3.4m and was filled by fills C.4 and C.10. The basal fill C.4 contained charred hazelnut shells, in addition to fragments of indeterminate burnt bone, 40 sherds of prehistoric pottery, in addition to flakes and fragments of struck quartz. The upper fill C.10 also contained 6 fragments of prehistoric pottery. An early Neolithic date range was returned from charcoal recovered from C.3. Depression C.12 was located *c*.0.20m north of C.3 and was possibly a continuation of C.3. 7 fragments of prehistoric pottery and several pieces of struck flint and quartz were recovered from C.12. Four post-holes, C.2, C.6, C.7 and C.16, were also recorded west of linear trench C.3. Fill C.5 of C.2 contained 2 fragments of prehistoric pottery and a split flint pebble. Post-holes C.6 and C.7 also contained 5 and 3 fragments of prehistoric pottery respectively.

Ceramics

The ceramic assemblage consisted of 62 fragments of prehistoric pottery from at least 6 vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). Fired quartz tempered clay was also recovered from C.3 and C.7, suggesting that pottery production may have occurred on site.

Lithics

The lithic assemblage consisted of struck flint and quartz flakes and a thumb nail scraper recovered during topsoil removal. The majority of lithics were recovered from the linear trench C.3.

Archaeobotanical remains

The archaeobotanical assemblage consisted of charred hazelnut, and indeterminate cereal grain, possibly emmer wheat. Charred hazelnut shells were recovered from fills C.4 and C.10 of linear trench C.3, fill C.5 of post-hole C.2, fill C.9 of post-hole C.6 and fills C.1, C.2 and C.3 of post-hole C.7. Cereal grains were recovered from fill C.9, C.1 and C.3, while charred apple pips were recovered from fill C.4 of linear feature C.3.

Radiocarbon dating

A single radiocarbon date was initially obtained following excavation (see Table B.41). Charcoal from C.3 returned a date range of 3796-3382 cal BC. Further radiocarbon dates were obtained as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Four radiocarbon determinations were obtained from charred wheat grains recovered from post-holes C.2 and C.6. All returned Early Neolithic dates ranges of 3708-3640 cal BC, 3708-3536 cal BC, 3661-3526 cal BC and 3767-3650 cal BC.

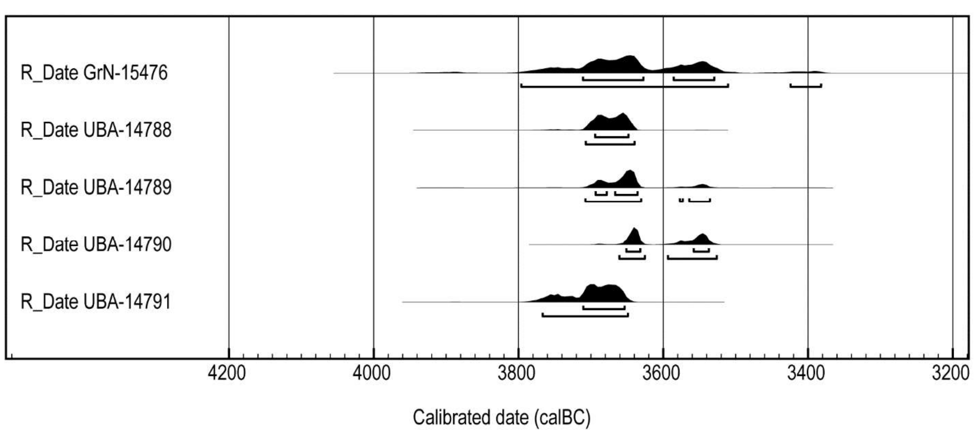

Figure B.91 Calibrated radiocarbon dates from Pepperhill

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
GrN-15476	C.3	Charcoal	4860±70	3796-3511 cal BC (92.7%) 3424-3382 cal BC (2.7%)	3712-3628 cal BC (47.2%) 3586-3530 cal BC (21.0%)
UBA-14788	C.2	Cereal grain	4892±28	3708-3640 cal BC	3694-3648 cal BC
UBA-14789	C.2	Hazelnut shell	4860±34	3708-3631 cal BC (85.8%) 3578-3574 cal BC (0.5%) 3564-3536 cal BC (9.1%)	3694-3678 cal BC (14.9%) 3667-3636 cal BC (53.3%)
UBA-14790	C.6	Wheat grain	4827±28	3661-3626 cal BC (45.1%) 3594-3526 cal BC (50.3%)	3652-3632 cal BC (38.2%) 3558-3538 cal BC (30.0%)
UBA-14791	C.6	Hazelnut shell	4926±30	3767-3650 cal BC	3711-3654 cal BC

Table B.41 Calibrated radiocarbon dates from Pepperhill

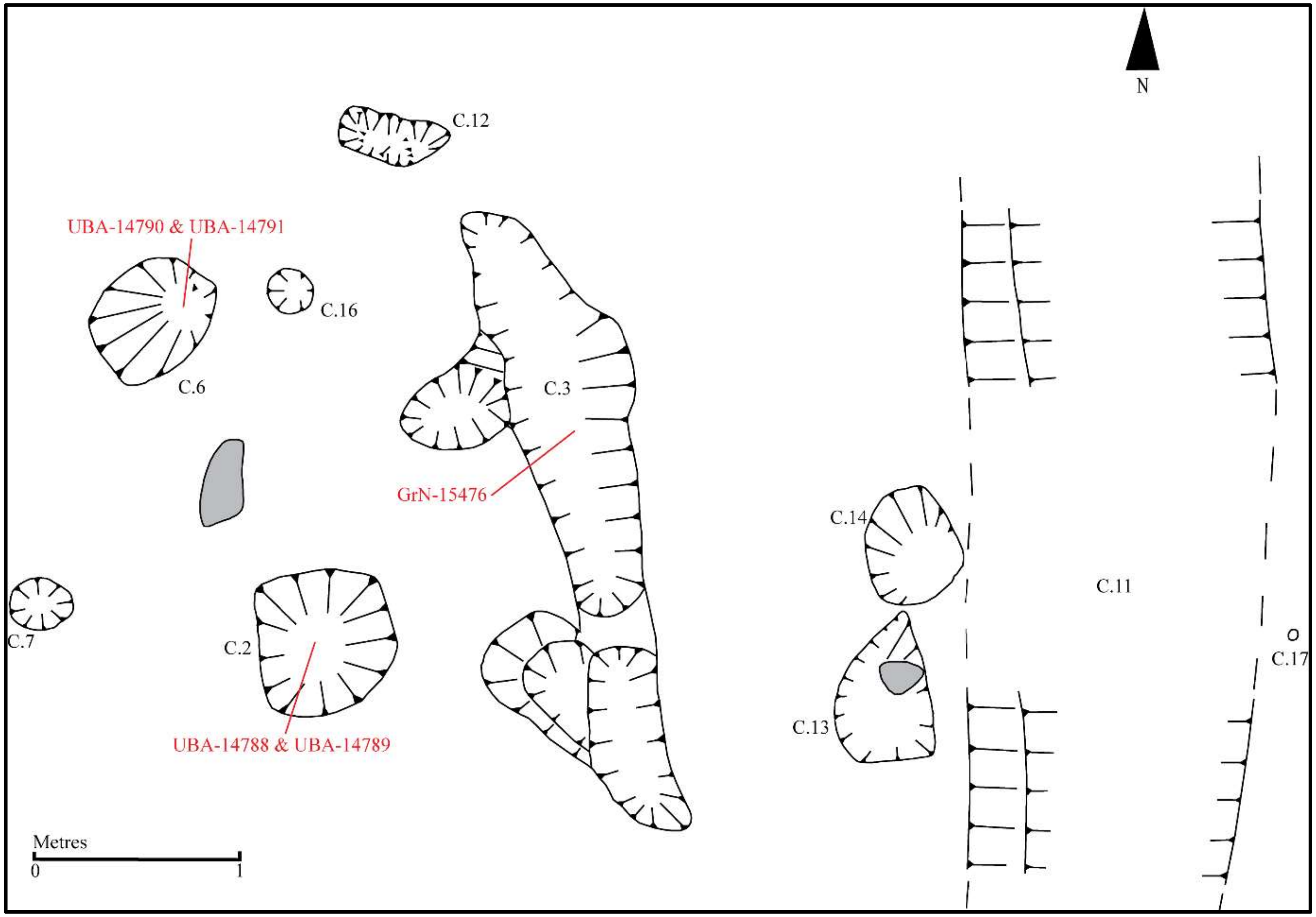

Figure B.92 Neolithic feature from Pepperhill

(67) Townland: Savagetown

Barony: Middlethird

County: Waterford

Site Type: Portal tomb

SMR: WA025-022----

Excavation Licence Number: N/A

ITM: 647375, 602522

National Grid: 247434, 102466

OD: 200-300m

Reference: (Mongey 1941, 13; Ó Nualláin 1983, 103; Moore 1999, 4)

The site is situated on a shelf on a gentle west facing slope *c*.4km north of the coast and facing towards the east. The roof-stone measuring *c*.3.4m in length with a maximum thickness of *c*.0.6m is resting on a portal-stone, *c*.1.2m high and a side-stone *c*.0.6m high. The back-stone is present, but the rest of the tomb is obscured by a field bank. The site has not been excavated.

(68) Townland: Scart
Barony: Knocktopher
County: Kilkenny
Site Type: Structure and pits
SMR:
Excavation Licence Number: E3001
ITM: 656766, 622635
National Grid: 256827, 122584
OD:
Reference: (Monteith 2011)

The site was identified in advance of roadworks on the N9/N10 Waterford to Kilcullen Road Scheme and was fully excavated between July and September 2006. Early Neolithic activity was recorded in Areas 1, 2 and 4.

Area 1

Early Neolithic activity in Area 1 was confined to 4 pits and a linear feature. Pit C.525 was filled by basal fill C.527 up to a depth of 0.55m. Charcoal from this fill was dated to the Early Neolithic period. This layer was subsequently sealed by fill C.526 and later truncated by curving linear cut C.301. Curvilinear cut C.301 extended from the north western edge of pit C.410 and curved southwards for a distance of 5.40m. Sealing the base of this cut was fill C.501, which was subsequently sealed by C.302. A single sherd of prehistoric pottery was also recovered from this upper layer. To the immediate east of these features a substantial kidney-shaped pit C.410 was identified. Four stratified layers were identified filling this cut with primary layer C.446 sealing the base. Overlying this material was a discreet deposit C.535 and fill C.411, which completely sealed C.535.

Area 2

Early Neolithic activity in Area 2 consisted of a structure (8) comprising numerous linear and post-hole features. Irregular linear C.867 was orientated in a north east – south west direction and measured 1.80m along this axis. The western side of the cut to the north had a pronounced step creating a stepped profile, contrasting with the ‘U-shaped’ profile recorded elsewhere along the length of the cut. North of this step possible stake hole C.1026 was recorded cutting the base of C.867. The base and eastern side of C.867 was sealed by a primary fill C.869 was post-dated by a subsequent deposit C.868 identified along the full length. To the immediate north of this slot trench two possible post holes C.1028 and C.1030 were identified. 8 small fragments of prehistoric pottery were recovered from fill C.1031 of C.1030. East-west orientated slot trench C.887 had a slightly 'waisted' shape in plan, becoming less wide towards the east where it was associated with post hole C.889.

Immediately south of this feature a similar circular post hole C.971 was identified. Sub-circular cut C.924 was recorded to the north of slot trench C.887. To the immediate east linear slot trench cut C.908 was identified with a similar east – west orientation, post hole C.913 was recorded cutting the natural base of this feature at its eastern extent. This cut had 'U-shaped' profile with steep sides and slightly concave base and was filled with C.914. Sealing this material and filling slot trench C.908 was fill C.909, containing a single small flint flake. North – south orientated linear cut C.1037 had two post holes, at either *termini*, were identified in association with this linear. The fill C.882 of the northern post hole C.870 contained 2 fragments of prehistoric pottery and a burnt flint flake. The fill C.845 of the southern post-hole C.844 contained a single small sherd of prehistoric pottery. A sample of charred hazelnut from this material returned an Early Neolithic date range. To the south slot trench C.1038 was recorded orientated in a north-north east/south-south west direction. Circular post-hole C.811 was recorded towards the northern extent of this feature. Fill C.827 covered the base and sides of this cut and was subsequently sealed by C.812. A single much worn sherd of prehistoric pottery and seven fragments of the same ceramic material were recovered from this upper fill. At the southern extent of linear C.1038 post hole C.813 was recorded and contained a deposit of sub-angular packing stones C.819 placed along the edges of the cut, and C.814 which filled this cut. Three sherds, of prehistoric pottery and a leaf-shaped arrowhead were recovered from this layer.

Area 4

An Early Neolithic radiocarbon date range was obtained for a sample of charred hazelnut shell from the sole fill C.271 of post-hole C.270, which formed part of Structure 6 in Area 4 of the site. Cultural material and a further radiocarbon date from a separate post hole of Structure 6 suggests the majority of activity in this general area dates to the Late Neolithic period. Structure 6 comprised a number of post and stake holes, as well as numerous internal and external pits of uncertain function or origin. There is some indication, therefore, that the early Neolithic material, while it may be residual, may represent an earlier phase of activity in the vicinity, albeit not clearly distinguishable from the later Neolithic structural evidence.

Ceramics

The ceramic assemblage consisted of 20 fragments of prehistoric pottery from at least 5 vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8).

Lithics

The lithic assemblage from Area 1 consisted of an end scraper made on a split pebble flake and an axe-shaped piece of weathered limestone. Area 2 produced 29 pieces of flint, in the form of knapping debris and finished tools were recovered from four separate features, C.299, C.307, C.348 and C.407.

Archaeobotanical remains

The archaeobotanical assemblage consisted of charred hazelnut, and indeterminate cereal grain, possibly emmer wheat. Charred hazelnut shells were identified in fill C.955 of post-hole C.940, fill C.845 of post-hole C.844, fill C.909 of slot-trench C.908, and in the fill C.930 of post-hole C.929 near Structure 8. In addition to hazelnut shell, post-hole fill C.930 also contained a grain of possible emmer wheat. A small number of hazelnut shell fragments were found in the fill C.271 of post-hole C.270 near Structure 6, which was a four-post and stake-hole structure.

Radiocarbon dating

There radiocarbon dates from the Early Neolithic were obtained during excavation (see Table B.42). Charred hazelnut shells from fill C.845 of post-hole C.844 (Area 2) and fill C.271 of post hole C.270 (Area 4) returned date ranges of 3702-3542 cal BC and 3909-3651 cal BC respectively. A further sample of oak charcoal from the lower fill C.527 of pit C.525 (Area 1) returned a date range of 3959 - 3791 cal BC.

ab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-13993	C.525	Oak Charcoal	5065±31	3956-3791 cal BC	3943-3908 cal BC (21.8%) 3879-3801 cal BC (46.4%)
UBA-13996	C.844	Hazelnut Shell	4861±28	3702-3633 cal BC (92.5%) 3552-3542 cal BC (2.9%)	3692-3686 cal BC (6.6%) 3662-3637 cal BC (61.6%)
Poz-26554	C.270	Hazelnut Shell	4960±40	3909-3878 cal BC (4.6%) 3802-3651 cal BC (90.8%)	3782-3695 cal BC

Table B.42 Calibrated radiocarbon dates from Scart

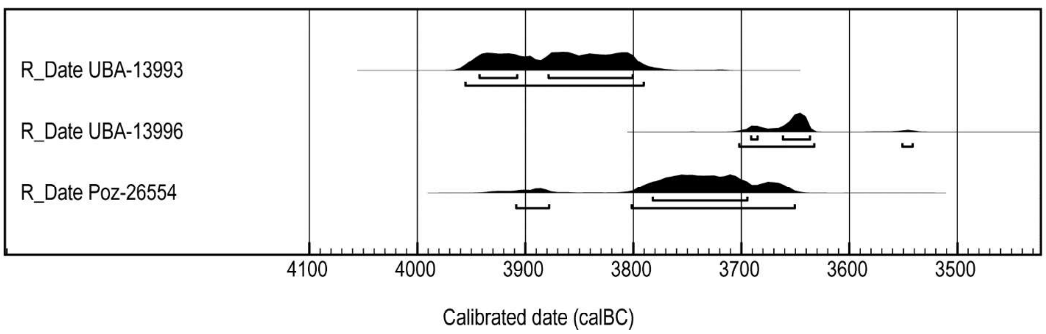

Figure B.93 Calibrated radiocarbon dates from Scart

(69) Townland: Shanagh (site 1)

Barony: Fermoy

County: Cork

Site Type: Pits, post-holes, stake-hole

SMR:

Excavation Licence Number: 12E0086

ITM: 566165, 609320

National Grid: 166207, 109266

OD:

Reference: (Ruttle 2013)

The site was identified in advance of roadworks on the Combined N73 Annakisha South and N73 Clogher Cross to Waterdyke, Co. Cork, Road Realignment Schemes and was fully excavated in April 2012. Five pits (C.2, C.3, C.4, C.5 & C.6), five post-holes (C.9, C.12, C.16, C.22 & C.25), a stake-hole (C.11) and a deposit (C.52) have been assigned to this phase. The features formed a roughly rectangular pattern, measuring 5.50m south-west to north-east by 5.0m south-east to north-west. The arrangement suggests a structure but because of the heavily ploughed nature of the site this can only be a tentative interpretation. Pottery and flint was found within fills C.52, C.53 (pit C.2), C.54 (pit C.3), C.57 (pit C.6) and C.72 (post-hole C.16) and pottery in fills C.56 (pit C.5), C.62 (post-hole C.12) and C.67 (post-hole C.9). A charred cereal grain from fill C.53 in pit C.2 and charred nutshell from fill C.57 in pit C.6 were both radiocarbon dated to the Early Neolithic. Post-hole C.9 appears to have been was reused or disturbed and contained two fills C.67 and C.60. Fill C.67, contained prehistoric pottery while fill C.60, contained post-medieval pottery. It is possible that fill C.67 was ploughed out and over time fill C.60 accumulated in the feature. A single stake-hole C.11 was recorded alongside small post-hole C.12, and they contained the same fill. Fill C.52 was located adjacent to features C.11 and C.12 and a charred nutshell from this deposit produced an Early Neolithic date range.

Ceramics

The ceramic assemblage consisted of 89 fragments of prehistoric pottery from at least 8 vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8). Early

Neolithic pottery was recovered within deposit C.52, fill C.53 of pit C.2, fill C.54 of pit C.3, fill C.56 of pit C.5, fill C.57 of pit C.6, fill C.62 of post-hole C.12 and fill C.67 of post-hole C.9.

Lithics

The lithic assemblage from Shanagh (site 1) consisted of fourteen pieces of worked flint, one utilised quartzite cobble and a possible modified Sandstone. The artefacts were recovered from a deposit C.52, the fill C.53 of pit C.2, the fill C.54 of pit C.3, the fill C.57 of pit C.6 and the fill C.60 of post-hole C.9. The flint artefacts and the quartzite rubbing stone are technologically and typologically diagnostic to a certain degree and most likely date to the Neolithic period (Woodman *et al.* 2006).

Archaeobotanical remains

The archaeobotanical assemblage consisted of charred cereal grains (wheat, barley and possible spelt) and charred hazelnut shells. Fragments of charred hazelnut shells were present in samples from pit C.6, post-hole C.22 and deposit C.52. Charred cereal grains were recorded from pits C.2 and C.6, deposit C.52 and post-hole C.22. Wheat most probably emmer wheat was identified in pit C.6, while grains tentatively identified as emmer/spelt type were also recorded from pits C.2 and C.6 and post-hole C.22. A single barley grain was also identified from post-hole 22.

Radiocarbon dating

Three radiocarbon dates were obtained from the features excavated at Shanagh 1, all of which were from short-lived material (see Table B.43). A charred hazelnut shell from fill C.53 of pit C.2 returned a radiocarbon date range of 3766-3532 cal BC, a charred hazelnut shell from deposit C.52 produced a radiocarbon date of 3758-3522 cal BC and a charred cereal grain from fill C.57 of pit C.6 returned a radiocarbon date range of 3796-3640 cal BC.

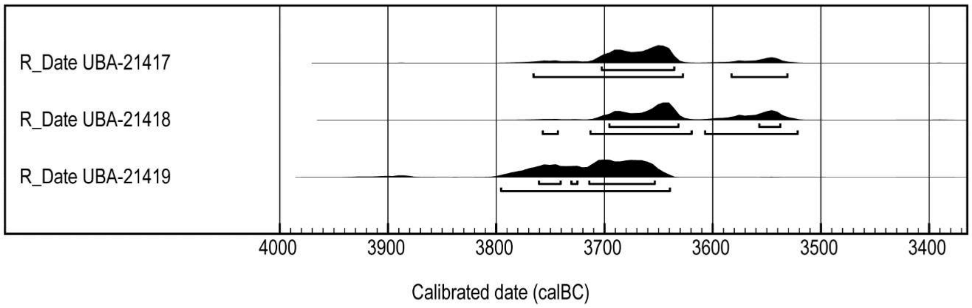

Figure B.94 Calibrated radiocarbon dates from Shanagh (site 1)

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-21417	C.2	Hazelnut Shell	4870±47	3766-3628 cal BC (82.8%) 3583-3532 cal BC (12.6%)	3703-3636 cal BC
UBA-21418	C.52	Hazelnut Shell	4850±47	3758-3744 cal BC (0.8%) 3714-3620 cal BC (63.5%) 3608-3522 cal BC (31.1%)	3696-3632 cal BC (55.0%) 3558-3538 cal BC (13.2%)
UBA-21419	C.6	Wheat Grain	4930±45	3796-3640 cal BC	3761-3741 cal BC (13.1%) 3731-3726 cal BC (3.3%) 3714-3654 cal BC (51.8%)

Table B.43 Calibrated radiocarbon dates from Shanagh (site 1)

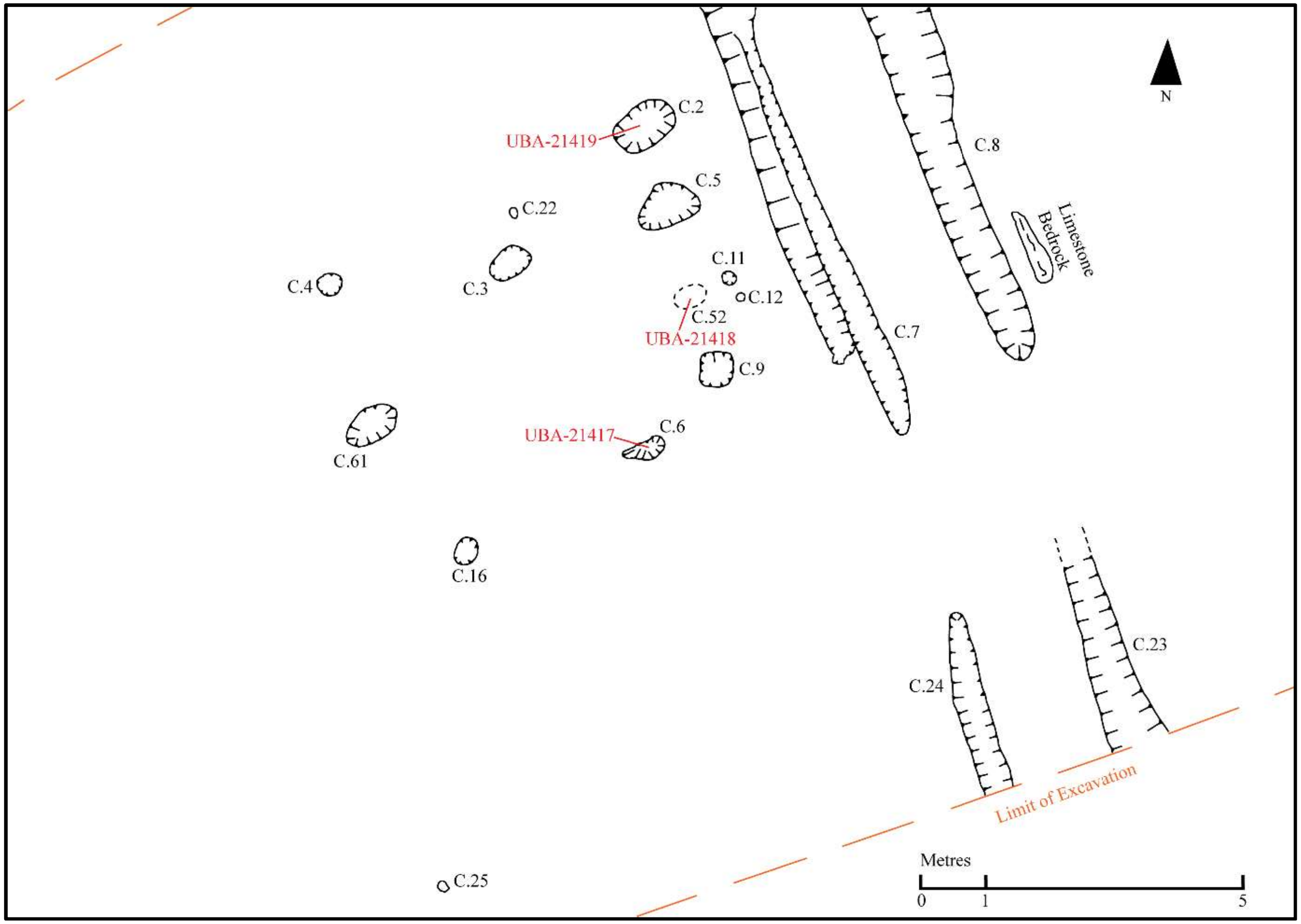

Figure B.95 Early Neolithic features from Shanagh (site 1)

(70) Townland: Sheskin

Barony: Upperthird

County: Waterford

Site Type: Portal tomb

SMR: WA003-023----

Excavation Licence Number: N/A

ITM: 637498, 620081

National Grid: 237555, 120029

OD: 300-400m

Reference: (Grubb 1944; Shee 1967; Ó Nualláin 1983, 102; Moore 1999, 4)

The site is situated at the side of a laneway, on a broad plateau at the head of a small east-west valley of a stream which meets the River Suir *c*.2km to the north. The site consists of a small ruined chamber of conglomerate stone. The two portal-stones remain and stand at a height of *c*.1.2m and *c*.1.35m, facing to the southeast. The rectangular roof-stone measures *c*.2.15m by *c*.2.2m and has a maximum thickness of *c*.0.45m. The roof-stone has slipped off its supporting stones, and the back-stone and the northeast side-stones are missing. The site has not been excavated.

(71) Townland: Suttonrath (site 206.1)
Barony: Iffa and Offa West
County: Tipperary
Site Type: Post-holes and pits
SMR:
Excavation Licence Number: E2128
ITM: 607672, 626076
National Grid: 207723, 126025
OD: 80-82m
Reference: (McQuade 2007b)

The site at Suttonrath (site 206.1) was identified in advance of roadworks on the N8 Cashel to Mitchelstown Road Improvement Scheme and was fully excavated between March and April 2006. The Early Neolithic phase of activity on site was represented by a series of pits and post-holes. The layout of these features did not form the ground plan of a coherent structure, but they are indicative of settlement activity on the site. There were three pits, C.1, C.2 and C.3, located on the eastern part of the site. A large oval pit C.3 was located on the east of the site. A smaller pit C.2 on the northeast end of the site was circular in plan and may have been used as a refuse pit. The pit was filled with C.13 which contained possible wheat grain and a few indeterminate cereal grains. An Early Neolithic date range was obtained for a sample of charcoal from the fill of this pit. A sub-oval pit C.1 was recorded on the southeast end of the site 12m southeast of the pit C.3. There were three post holes C.11, C.7 and C.14 on this site. Two of these C.11 and C.7 were in close proximity to pits C.3 and C.1 and were probably associated with them. There was an isolated post hole C.14 on the centre of the site.

Archaeobotanical remains

The archaeobotanical remains consisted of a possible wheat grain and four indeterminate cereal grains were recovered from fill C.13 of pit C.2 at Suttonrath (site 206.1).

Radiocarbon dating

A single radiocarbon date was initially obtained following excavation (see Table B.44), charcoal from fill C.13 from pit C.2 returned a date range of 3637-3378 cal BC. An additional two radiocarbon dates were obtained for Suttonrath (site 206.1) as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Charred cereal grains from fill C.13 from pit C.2 returned date ranges of 3641-3523 cal BC and 3640-3521 cal BC.

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UB-7208	C.2	Charcoal	4744 ± 36	3637-3500 cal BC (75.4%) 3432-3378 cal BC (20.0%)	3633-3556 cal BC (49.1%) 3539-3516 cal BC (14.0%) 3396-3386 cal BC (5.1%)
UBA-14809	C.2	Wheat	4789 ± 24	3641-3622 cal BC (15.0%) 3604-3523 cal BC (80.4%)	3637-3630 cal BC (8.2%) 3578-3534 cal BC (60.0%)
UBA-14810	C.2	Cereal	4778 ± 26	3640-3618 cal BC (14.7%) 3611-3521 cal BC (80.7%)	3634-3628 cal BC (6.2%) 3586-3530 cal BC (62.0%)

Table B.44 Calibrated radiocarbon dates from Suttonrath (site 206.1)

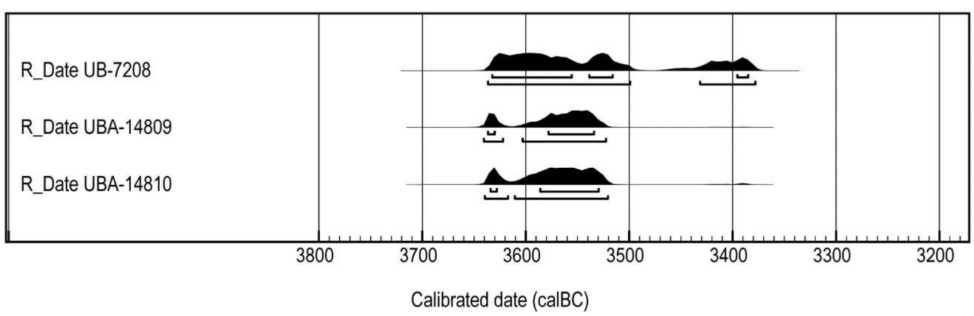

Figure B.96 Calibrated radiocarbon dates from Suttonrath (site 206.1)

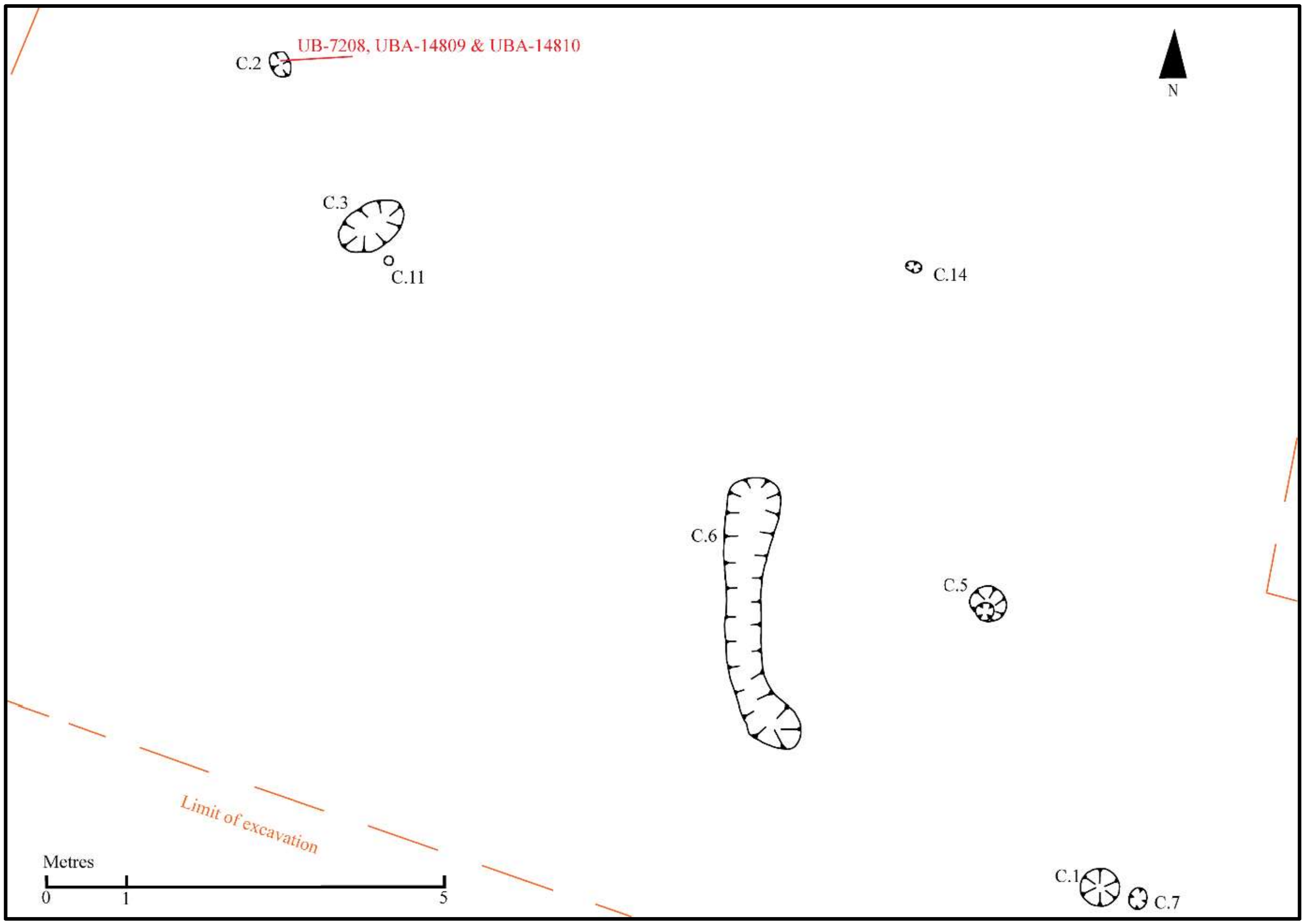

Figure B.97 Early Neolithic features from Suttonrath (site 206.1)

(72) Townland: Tankardstown South

Barony: Coshma

County: Limerick

Site Type: Neolithic Rectangular Houses

SMR: LI047-012001-

Excavation Licence Number: E372

ITM: 558357, 628286

National Grid: 158397, 128236

OD: 90m

Reference: (Gowen 1988, 26-43; Gowen and Tarbett 1988; 1989; 1990)

Two structures were excavated at Tankardstown South, County Limerick in advance of gas pipeline construction. Both structures were defined by a foundation trench, with structure 1 aligned on a north-east south-west axis and structure 2 on an east-northeast west-southwest alignment. Structure 1 showed no evidence of internal division while structure 2 demonstrated two internal cross-divisions.

Structure 1

Structure 1 measured 7.4m by 6.4m, giving a total surface are of *c.*47m², structure 1 was defined by a continuous foundation trench C.1, with a two post-holes C.72 and C.83 mid-way along both the north and south foundation trenches. C.1 was filled by three fills C.5, C.8 and C.68. Sherds of prehistoric pottery and burnt animal bone was recovered from fills C.8 and C.68. Two internal post-holes C.23 and C.41 likely represented internal roof supports. A number of other internal features C.40, C.43 and C.52 were also identified but could not be definitively described as features. Two further post-holes C.4 and C.77 were identified outside the southern and northern foundation trench and may have been external roof supports.

Structure 2

Structure 2 lies *c.*20m to the north west of structure 1. The house appears to have maximum external dimensions of *c.*15.5m in length and *c.*7.5m in width, giving a larger surface are of 112.5m². It has two narrow annexes, one at either end of a large central area. The central 'compartment' measures *c.*9.2m in length. The extent of the structure was defined by foundation trench C.4. No obvious internal post holes, such as those crossing the short axis of structure 1, have yet been revealed in the central compartment, although a shallow pit C.103, may constitute the base of a truncated post-hole. At the eastern end of the house the features constitute the north-eastern corner of the house and annexe, the external wall of the annexe being defined by a large corner post-hole C.78 and a short slot-trench C.2 and an opposing corner post-hole C.63. The only other definite Neolithic feature excavated was a very short slot-gully C.122 lying to the south of the foundation trench in the south-east quadrant. All the Neolithic features excavated, without exception, produced sherds and fragments of prehistoric pottery.

Ceramics

The majority of the pottery was recovered from the foundation trench C.1 of structure 1 and represented at least 11 vessels of Neolithic pottery. Sixty-seven sherds of pottery were also recovered from structure 2. All vessels which were identified as Early Neolithic Carinated Bowls, which represent the earliest type of Neolithic pottery (Case 1961, 175-177; Sheridan 1995, 6-8).

Lithics

The lithic assemblage from structure 1 consisting of a lozenge-shaped flint arrowhead, flint flakes, a chert scraper and a quartz end scraper Flint recovered from structure 2 included a leaf shaped blade, a rough point, ten struck flakes.

Archaeobotanical remains

The archaeobotanical assemblage included emmer wheat grain, emmer wheat glume, apple endocarp, apple pips, indeterminate cereal grain, hazelnut shells, possible barley grain and the seeds of ruderal taxa associated with cultivation.

Archaeozoological remains

The archaeozoological assemblage included bones from cattle, sheep/goat, unidentified large mammals, cattle/red deer, medium sized mammals (pig/sheep/goat), pig, bird and the remains of several unidentifiable smaller mammals.

Radiocarbon dating

Following the initial phases of excavation, seven radiocarbon dates were obtained for Tankardstown South. However, only two were from short-lived material, emmer wheat grains. Both returned Early Neolithic date ranges of 3942-3386 cal BC and 3708-3522 cal BC respectively. The remaining five dates were from bulk oak charcoal and returned date ranges of 3984-3790 cal BC,3934-3707 cal BC, 3948-3378 cal BC, 3906-3706 cal BC and 3951-3798 cal BC. Further radiocarbon dates were obtained as part of the Heritage Council funded *Cultivating Societies; assessing the evidence for agriculture in Neolithic Ireland* (McClatchie *et al.* 2014; Whitehouse *et al.* 2014; McLaughlin *et al.* 2016). Ten radiocarbon dates were obtained from wheat grains and all dated to the Early Neolithic (see Table B.46).

These ten dates (*UBA-14734, UBA-14735, UBA-14736, UBA-14737, UBA-14738, UBA-14739, UBA-14740, UBA-14742, UBA-14743* and *UBA-14780*) and the two original dates, *OxA1476* and *OxA-1477*, were plotted using OxCal 4.2.4 (Bronk Ramsey 2009a) to propose refined dates for the start and end of the Early Neolithic occupation at Tankardstown South. The dates from oak charcoal (*GrN-14713, GrN-15386, GrN-15387, GrN-16557* and *GrN-16558)* have been treated as *termini post quos* for construction of the structures at Tankardstown South. Bayesian modelling returned a date range of *3780-3660 cal BC (95% probability), 3740-3670 cal BC (68% probability)* for the start of occupation at Tankardstown South and a date range of *3700-3620 cal BC (95% probability), 3680-3640 cal BC (68% probability)* for the end of occupation ($A_{overall}$=92.7). The model also proposed a duration of activity at Tankardstown South of between *0-110 years (95% probability), 0-70 years (68% probability)*.

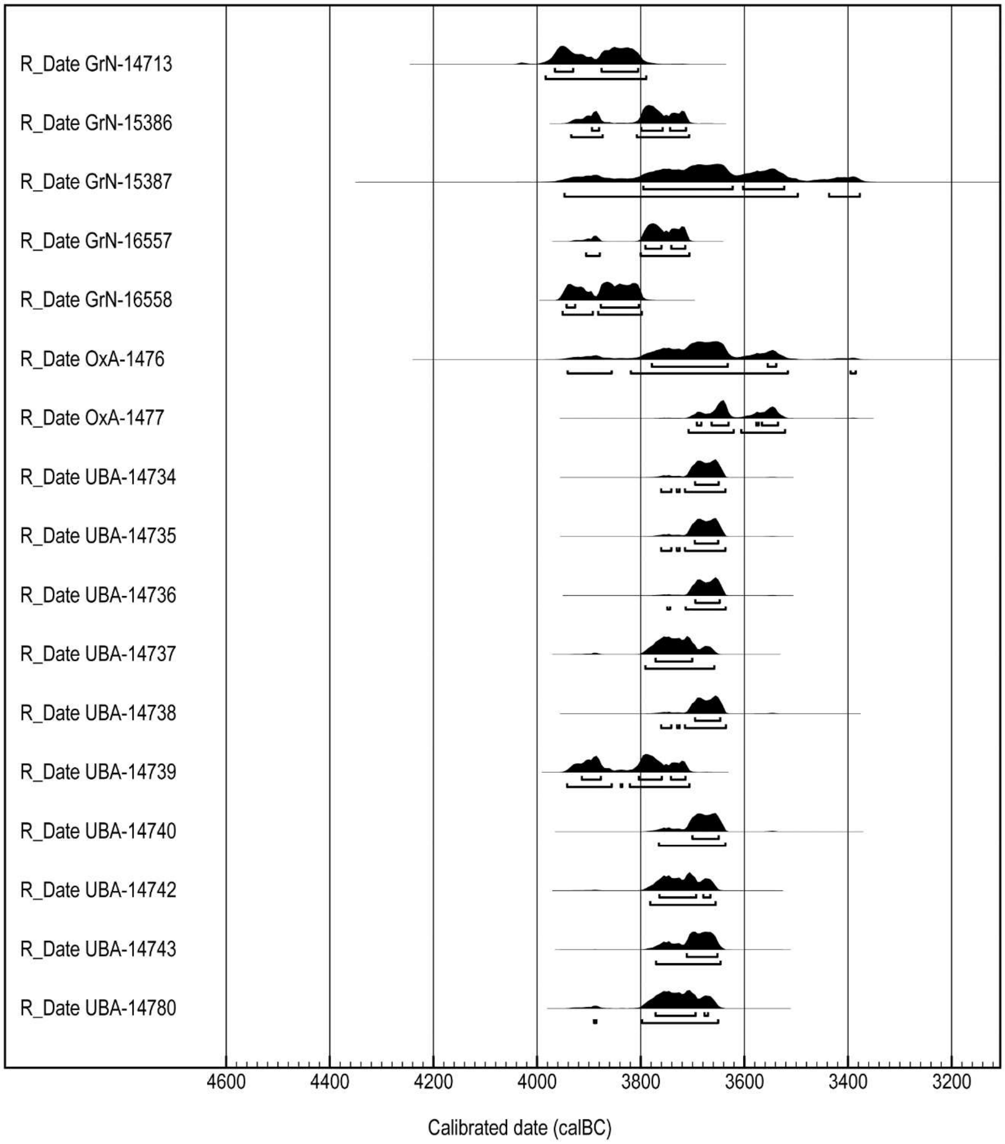

Figure B.98 Calibrated radiocarbon dates from Tankardstown South

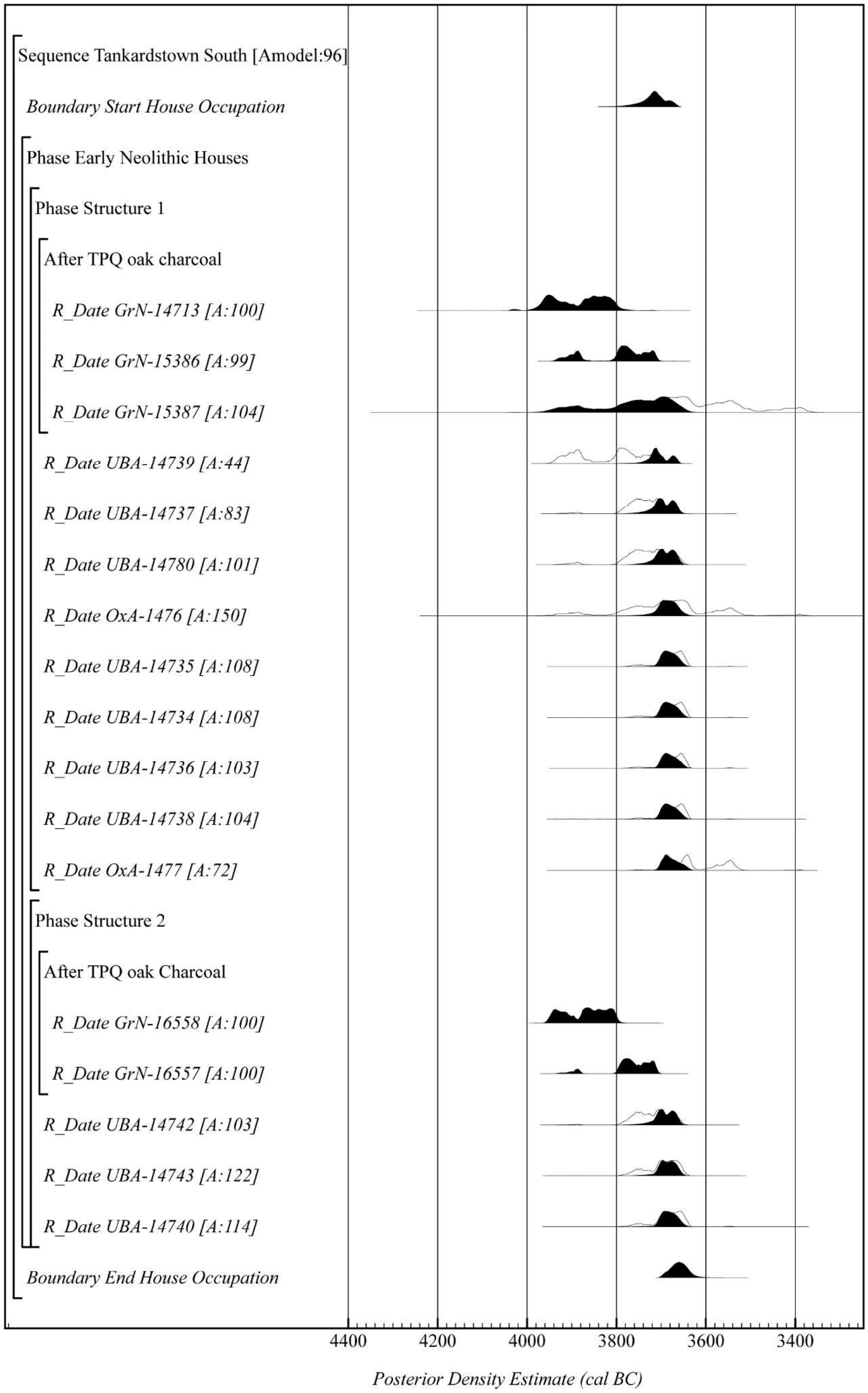

Figure B.99 Bayesian model for occupation at Tankardstown South

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
GrN-14713	H1 C.1	Oak Charcoal	5105±45	3984-3790 cal BC	3966-3931 cal BC (22.9%) 3876-3806 cal BC (45.3%)
GrN-15386	H1 C.1	Oak Charcoal	5005±25	3934-3874 cal BC (24.6%) 3808-3707 cal BC (70.8%)	3894-3881 cal BC (9.1%) 3800-3758 cal BC (38.6%) 3744-3713 cal BC (20.5%)
GrN-15387	H1 C.1	Oak Charcoal	4880±110	3948-3498 cal BC (89.7%) 3437-3378 cal BC (5.7%)	3796-3623 cal BC (50.3%) 3603-352 cal 4BC (17.9%)
GrN-16557	H2	Oak Charcoal	4995±20	3906-3880 cal BC (7.1%) 3800-3706 cal BC (88.3%)	3792-3760 cal BC (39.9%) 3742-3714 cal BC (28.3%)
GrN-16558	H2	Oak Charcoal	5070±20	3951-3893 cal BC (33.7%) 3882-3798 cal BC (61.7%)	3944-3927 cal BC (11.9%) 3878-3804 cal BC (56.3%)
OxA-1476	H1 C.23	Emmer Wheat Grain	4890±80	3942-3857 cal BC (7.0%) 3820-3517 cal BC (87.9%) 3396-3386 cal BC (0.5%)	3779-3633 cal BC (63.6%) 3556-3539 cal BC (4.6%)
OxA-1477	H1 C.23	Emmer Wheat Grain	4840±45	3708-3621 cal BC (55.1%) 3606-3522 cal BC (40.3%)	3692-3684 cal BC (4.8%) 3664-3631 cal BC (36.4%) 3578-3573 cal BC (2.5%) 3566-3536 cal BC (24.5%)
UBA-14734	H1 C.1	Wheat Grain	4895±33	3761-3742 cal BC (3.3%) 3731-3726 cal BC (0.7%) 3715-3637 cal BC (91.4%)	3696-3650 cal BC
UBA-14735	H1 C.1	Wheat Grain	4897±32	3761-3742 cal BC (3.3%) 3731-3726 cal BC (0.7%) 3715-3637 cal BC (91.4%)	3696-3651 cal BC

Table B.45 Calibrated radiocarbon dates from Tankardstown South

Lab Code	Context	Dated Material	Radiocarbon Age (Years BP)	Calibrated Age (2σ) 95.4% Probability	Calibrated Age (1σ) 68.2% Probability
UBA-14736	H1 C.41	Wheat Grain	4891±31	3749-3744 cal BC (0.6%) 3714-3636 cal BC (94.8%)	3695-3648 cal BC
UBA-14737	H1 C.41	Wheat Grain	4958±30	3792-3658 cal BC	3772-3701 cal BC
UBA-14738	H1 C.23	Wheat Grain	4890±33	3761-3742 cal BC (2.5%) 3730-3726 cal BC (0.5%) 3715-3636 cal BC (92.4%)	3696-3647 cal BC
UBA-14739	H1 C.23	Wheat Grain	5013±31	3942-3856 cal BC (37.5%) 3839-3836 cal BC (0.4%) 3822-3706 cal BC (57.6%)	3914-3878 cal BC (23.0%) 3804-3760 cal BC (31.6%) 3742-3714 cal BC (13.7%)
UBA-14740	H2 C.4	Wheat	4899±37	3766-3637 cal BC	3700-3650 cal BC
UBA-14742	H2 C.171	Cereal	4947±30	3782-3656 cal BC	3764-3694 cal BC (58.2%) 3680-3666 cal BC (10.0%)
UBA-14743	H2 C.171	Wheat	4923±33	3771-3646 cal BC	3712-3652 cal BC
UBA-14780	H1 C.1	Wheat Grain	4952±38	3890-3886 cal BC (0.6%) 3798-3651 cal BC (94.8%)	3772-3694 cal BC (63.6%) 3678-3670 cal BC (4.6%)

Table B.46 Calibrated radiocarbon dates from Tankardstown South

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 95.5 Aoverall 92.7				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Tankardstown South																	
Boundary Start House Occupation							-3740	-3679	68.2	-3774	-3664	95.4					96.2
Phase Early Neolithic Houses																	
Phase Structure 1																	
After TPQ oak charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3985	-3790	95.4		99.7			99.9
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			100
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3892	-3658	68.2	-3944	-3646	95.4		104.2			99.7
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3726	-3667	68.2	-3747	-3659	95.4		44.4			97
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3715	-3665	68.2	-3743	-3656	95.4		83.1			98.7
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3710	-3666	68.2	-3739	-3653	95.4		100.8			99.2
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3705	-3664	68.2	-3734	-3642	95.4		149.5			99.5
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3701	-3667	68.2	-3711	-3648	95.4		108			99.6
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3701	-3667	68.2	-3711	-3647	95.4		107.7			99.6
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3701	-3666	68.2	-3708	-3649	95.4		103			99.6
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3701	-3666	68.2	-3710	-3648	95.4		104.3			99.6
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3701	-3664	68.2	-3707	-3641	95.4		72.4			99.4
Phase Structure 2																	
After TPQ oak Charcoal	-3740	...	68.2	-3713	...	95.4											
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.5			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3792	-3715	68.2	-3906	-3707	95.4		99.5			100
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3710	-3666	68.2	-3737	-3655	95.4		102.6			99.3
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3704	-3667	68.2	-3723	-3650	95.4		121.7			99.6
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3702	-3667	68.2	-3714	-3647	95.4		114.2			99.7

Span Occupation of Early Neolithic Houses	0	63	68.2	0	108	95.4	82.3
Boundary End House Occupation	-3680	-3641	68.2	-3700	-3624	95.4	98.3

Table B.47 Bayesian model for occupation at Tankardstown South

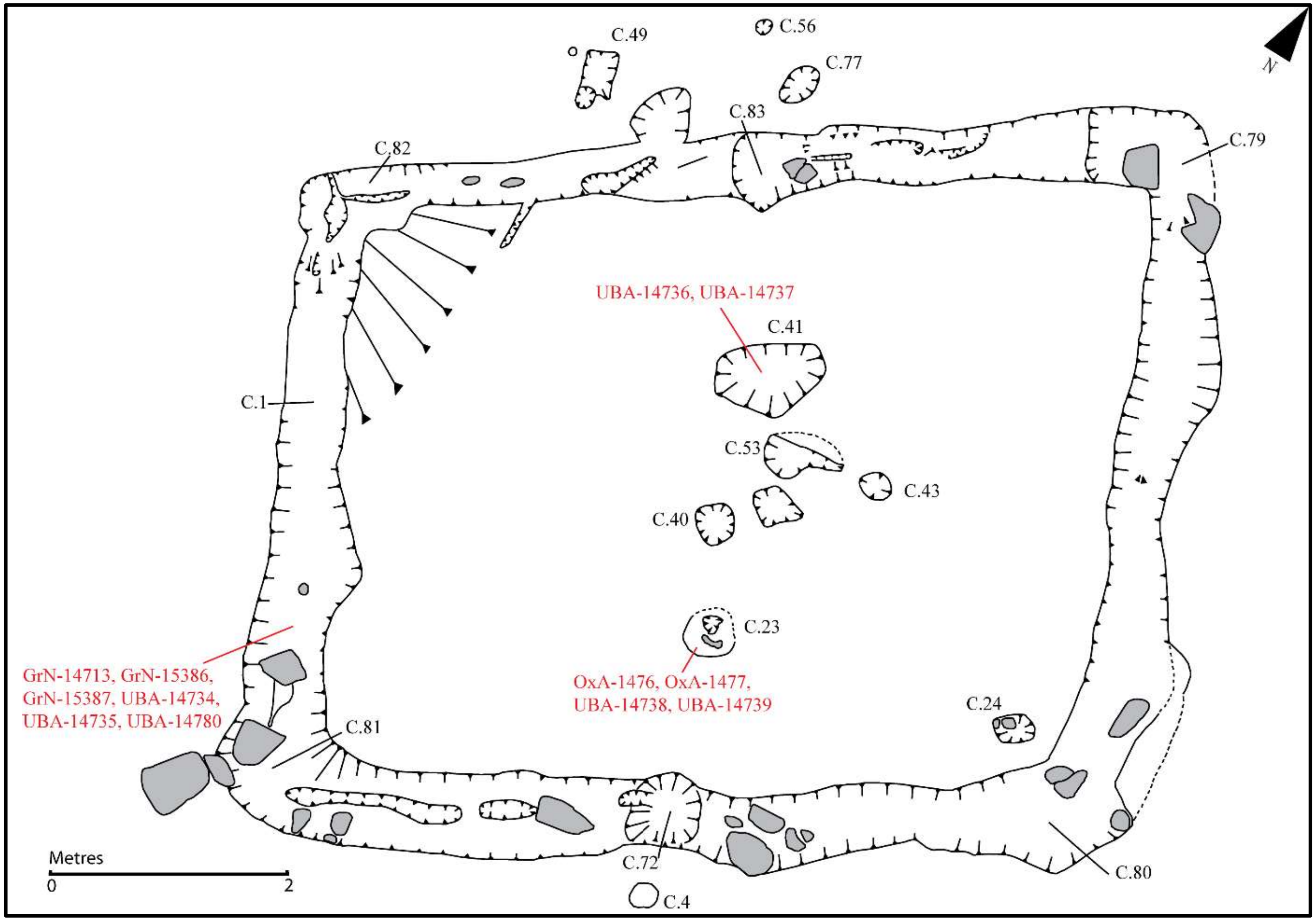

Figure B.100 Early Neolithic Rectangular House 1, from Tankardstown South

(73) Townland: Whitestown East

Barony: Decies without Drum

County: Waterford

Site Type: Portal tomb

SMR: WA007-024----

Excavation Licence Number: N/A

ITM: 642414, 613897

National Grid: 242472, 113844

OD: 100-200m

Reference: (Powell 1941; Ó Nualláin 1983, 103; Moore 1999, 4)

The site is located in pasture towards the bottom of the northwest facing slope of a valley, with a southwest-northeast stream *c.*80m to the southeast which joins the River Suit *c.*7km to the northeast. The portal tomb is constructed of Old Red Sandstone conglomerate. A sub circular roof-stone, measuring *c.*4m by *c.*3.3m with thickness of between *c.*0.4 to *c.*1m is sitting on a collapsed chamber. The original chamber was probably facing southeast and is now built into the northeast side of a northwest-southeast field bank. There are some upright stones beneath the roof-stone. The site has not been excavated.

Appendix C - Bayesian model specifications

C.1. Bayesian Models outlined in Chapter 4

C.1.1. Bayesian model for Early Neolithic House sites

```
Plot("Early Neolithic Houses")
 {
  Sequence("House South of Ireland")
  {
   Boundary("Start House Occupation");
   Phase("Houses")
   {
    Phase("Ballinglanna North (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("UB-13145", 5010, 25);
      R_Date("UB-13146", 5007, 28);
     };
     R_Date("UBA-10499", 4936, 21);
    };
    Phase("Barnagore (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("Beta-171411", 4880, 70);
      R_Date("Beta-171412", 4950, 70);
     };
    };
    Phase("Caherdrinny (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("UBA-13289", 4877, 26);
      R_Date("UB-13284", 5138, 27);
      R_Date("UB-13286", 4926, 26);
      R_Date("UBA-13292", 5214, 27);
     };
    };
    Phase("Cloghers")
    {
     R_Date("Beta-134227", 4900, 40);
     R_Date("Beta-134226", 4850, 40);
    };
    Phase("Earlsrath")
    {
     After("TPQ Charcoal")
     {
      R_Date("UBA-14153", 4912, 30);
      R_Date("UBA-14160", 4917, 31);
      R_Date("UBA-14154", 5239, 31);
     };
     R_Date("UBA-14158", 4835, 41);
```

```
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
 };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
```

```
  };
  Phase("Tankardstown South")
  {
   After("TPQ Charcoal")
   {
    R_Date("GrN-14713", 5105, 45);
    R_Date("GrN-15387", 4880, 110);
    R_Date("GrN-15386", 5005, 25);
    R_Date("GrN-16558", 5070, 20);
    R_Date("GrN-16557", 4995, 20);
   };
   R_Date("OxA-1476", 4890, 80);
   R_Date("UBA-14739", 5013, 31);
   R_Date("UBA-14780", 4952, 38);
   R_Date("UBA-14737", 4958, 30);
   R_Date("UBA-14734", 4895, 33);
   R_Date("UBA-14735", 4897, 32);
   R_Date("UBA-14738", 4890, 33);
   R_Date("UBA-14736", 4891, 31);
   R_Date("OxA-1477", 4840, 45);
   R_Date("UBA-14742", 4947, 30);
   R_Date("UBA-14743", 4923, 33);
   R_Date("UBA-14740", 4899, 37);
  };
  Span("Duration House South of Ireland");
 };
 Boundary("End House Occupation");
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 126 Aoverall 126.6				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence House South of Ireland																	
Boundary Start House Occupation							-3711	-3678	68.2	-3721	-3669	95.4					95.3
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.3	-3938	-3708	95.4		99.1			99.9
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.3			99.9
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3686	-3657	68.2	-3706	-3654	95.4		110.2			99.2
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3757	-3635	68.2	-3905	-3627	95.4		114.8			99.9
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3792	-3653	68.2	-3942	-3638	95.4		101.8			99.9
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3700	-3639	95.4		99.7			100
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3982	-3847	68.2	-4033	-3808	95.3		99.5			99.9
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3650	95.4		99.3			100
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4041	-3981	68.2	-4054	-3963	95.4		99.6			99.9
Phase Cloghers																	
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3684	-3647	68.2	-3701	-3639	95.4		119.4			99.5
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3664	-3634	68.2	-3696	-3631	95.4		129.7			99.8
Phase Earlsrath																	
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4											
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.7			99.9

R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.6			99.9
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4054	-3981	68.2	-4227	-3970	95.3		99.8			99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3659	-3632	68.2	-3691	-3629	95.4		126.8			99.9
Phase Gortore (site 1)																	
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4											
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3928	-3655	95.4		99.9			99.9
Phase Granny (site 27)																	
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4											
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3702	-3650	68.2	-3765	-3638	95.4		100.5			99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.1	-3960	-3718	95.4		99.9			99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		99.9			99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3685	-3654	68.2	-3706	-3646	95.4		119.3			99.2
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3686	-3651	68.2	-3702	-3644	95.4		115.5			99.4
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3685	-3653	68.2	-3703	-3646	95.4		118.2			99.4
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3679	-3643	68.2	-3697	-3638	95.4		108.7			99.6
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3642	-3629	68.2	-3654	-3622	95.4		84.9			99.9
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3647	-3636	68.2	-3657	-3631	95.4		127.4			100
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3669	-3636	68.2	-3696	-3633	95.4		125.4			99.8
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3667	-3636	68.2	-3694	-3633	95.4		119.4			99.9
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3660	-3633	68.2	-3691	-3630	95.4		129.7			99.9
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3653	-3632	68.2	-3691	-3626	95.4		112.4			99.9
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3643	-3629	68.2	-3657	-3622	95.4		85.8			99.8
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3644	-3631	68.2	-3653	-3626	95.4		95.5			99.9
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3638	-3628	68.2	-3645	-3622	95.4		74.3			99.7
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											

R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3709	-3633	68.2	-3796	-3626	95.4		115.9			99.9
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3685	-3655	68.2	-3706	-3647	95.4		118.6			99.3
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3682	-3647	68.2	-3698	-3641	95.4		105.9			99.6
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3667	-3636	68.2	-3693	-3634	95.4		118			99.8
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3648	-3634	68.2	-3663	-3627	95.4		128.8			99.9
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3686	-3651	68.2	-3706	-3642	95.4		116.8			99.3
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3676	-3638	68.2	-3698	-3633	95.4		130.5			99.7
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3668	-3634	68.2	-3696	-3631	95.4		134			99.8
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3790	95.4		99.8			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3780	-3633	68.2	-3943	-3628	95.4		112.6			99.8
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.1			99.9
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.4			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3792	-3715	68.2	-3906	-3707	95.4		99.5			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3680	-3640	68.2	-3703	-3631	95.4		151.9			99.5
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3710	-3660	68.2	-3718	-3657	95.4		11			97.8
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3686	-3655	68.2	-3710	-3648	95.4		84.6			99.2
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3687	-3657	68.2	-3711	-3653	95.4		59.3			99
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3683	-3647	68.2	-3699	-3640	95.4		110.8			99.5
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3683	-3648	68.2	-3700	-3641	95.4		110.3			99.5
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3679	-3645	68.2	-3698	-3639	95.4		109.9			99.6
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3680	-3646	68.2	-3697	-3640	95.4		108.2			99.6
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3664	-3632	68.2	-3693	-3630	95.4		129.6			99.9
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3686	-3656	68.2	-3710	-3651	95.4		88.4			99.1
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3685	-3654	68.2	-3705	-3646	95.4		119.6			99.2
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3684	-3647	68.2	-3700	-3640	95.4		116.1			99.5
Span Duration House South of Ireland							45	79	68.2	32	92	95.4					95.8

Boundary End House Occupation				-3636	-3624	68.2	-3640	-3618	95.4					99.2

Table C.1 Bayesian model for occupation of Early Neolithic houses in the southern region of Ireland

C.1.2. Bayesian model for Early Neolithic Ephemeral sites

```
Plot("Early Neolithic Ephemeral Sites")
 {
  Sequence("Early Neolithic ephemeral sites in the South of Ireland")
  {
   Boundary("Start Occupation");
   Phase("Ephemeral Sites")
   {
    Phase("Ballinaspig More (site 4)")
    {
     After("TPQ Charcoal")
     {
      R_Date("Beta-178204", 5050, 50);
     };
    };
    Phase("Ballinaspig More (Site 5)")
    {
     After("TPQ Oak Charcoal")
     {
      R_Date("Beta-178206", 5030, 70);
      R_Date("Beta-178210", 4990, 70);
     };
     R_Date("Beta-178211", 4860, 70);
    };
    Phase("Bawnfune (site 2) ")
    {
     After("TPQ Charcoal")
     {
      R_Date("Poz-24934 ", 4880, 40);
     };
    };
    Phase("Caherabbey Upper (site 185.1-4)")
    {
     After("TPQ Oak Charcoal")
     {
      R_Date("UB-7236", 5119, 38);
     };
     R_Date("UBA-14411", 4822, 30);
     R_Date("UBA-14408", 4856, 30);
     R_Date("UBA-14409", 4850, 29);
     R_Date("UBA-14406", 4849, 28);
     R_Date("UBA-14407", 4801, 28);
    };
    Phase("Curraghprevin (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("Beta-201069", 4720, 80);
     };
```

```
};
Phase("Danganbeg (site 10-5)")
{
 R_Date("UBA-24492", 4788, 33);
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
 {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13720", 4822, 32);
 };
};
Phase("Newrath (site 35)")
{
 R_Date("UB-6639", 4827, 39);
 R_Date("UBA-14798", 4809, 26);
```

```
  R_Date("UB-6640", 4821, 38);
  R_Date("UBA-14799", 4754, 27);
 };
 Phase("Scart")
 {
  R_Date("Poz-26554", 4960, 40);
  R_Date("UBA-13996", 4861, 28);
  After("TPQ Oak Charcoal")
  {
   R_Date("UBA-13993", 5065, 31);
  };
 };
 Phase("Suttonrath (site 206.1)")
 {
  R_Date("UBA-14809", 4789, 28);
  R_Date("UBA-14810", 4778, 28);
  R_Date("UB-7208", 4744, 36);
 };
 Span("Duration of Occupation");
};
Boundary("End Occupation");
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 110.4 Aoverall 111.5				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic ephemeral sites in the South of Ireland																	
Boundary Start Occupation							-3680	-3654	68.2	-3705	-3648	95.4					98.7
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3942	-3792	68.2	-3961	-3713	95.4		99.9			99.7
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3716	68.2	-3965	-3666	95.4		100			99.5
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3932	-3696	68.2	-3946	-3656	95.4		100			99.4
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3666	-3540	68.2	-3680	-3532	95.4		117.1			99.8
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3765	-3541	95.4		100.4			99.7
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.6			99.5
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3650	-3539	68.2	-3657	-3532	95.4		100.6			99.8
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3660	-3636	68.2	-3686	-3537	95.4		116.1			99.9
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3657	-3635	68.2	-3674	-3537	95.4		112.4			99.9
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3656	-3635	68.2	-3672	-3537	95.4		110.9			99.9
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3641	-3539	68.2	-3648	-3531	95.4		98.9			99.8
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											

R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3633	-3560	68.2	-3657	-3520	95.4		100.2			99.7
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3639	-3539	68.2	-3644	-3530	95.4		103			99.9
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3770	-3637	95.4		100.1			99.6
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3656	-3541	68.2	-3667	-3533	95.4		106.9			99.9
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3641	-3539	68.2	-3649	-3530	95.4		101.3			99.9
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3641	-3538	68.2	-3647	-3530	95.4		103.8			99.9
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3638	-3539	68.2	-3644	-3530	95.4		104.2			99.9
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3660	-3539	68.2	-3675	-3531	95.4		111.4			99.9
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3799	-3652	95.4		100			99.7
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3953	68.2	-4045	-3818	95.4		99.6			99.6
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3942	-3776	68.2	-3951	-3713	95.4		99.9			99.7
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.8			99.7
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3651	-3539	68.2	-3662	-3529	95.4		99.4			99.8
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3653	-3539	68.2	-3665	-3529	95.4		106.8			99.9
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3644	-3539	68.2	-3651	-3531	95.4		97.5			99.9
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3651	-3539	68.2	-3661	-3529	95.4		104.5			99.9
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3632	-3561	68.2	-3636	-3529	95.4		109.3			99.9

Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3670	-3648	68.2	-3687	-3640	95.4		50.9			99.1
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3658	-3638	68.2	-3686	-3540	95.4		117.8			99.9
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.7			99.7
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3638	-3540	68.2	-3643	-3530	95.4		100.6			99.8
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3636	-3541	68.2	-3640	-3529	95.4		102.7			99.9
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3631	-3565	68.2	-3636	-3530	95.4		114.7			99.9
Span Duration of Occupation							108	139	68.2	93	163	95.4					99.4
Boundary End Occupation							-3546	-3521	68.2	-3561	-3504	95.4					99.5

Table C.2 Bayesian model for occupation of Early Neolithic ephemeral sites in the southern region of Ireland

C.1.3. Bayesian model for Early Neolithic Burials

```
Plot(“Early Neolithic Burials”)
 {
  Sequence("Neolithic Burials")
  {
   Boundary("Start Burials");
   Phase("Burials")
   {
    Phase("Annagh")
    {
     R_Date("GrA-1709", 4840, 60);
     R_Date("GrA-1707", 4810, 60);
     R_Date("GrA-1704", 4780, 60);
     R_Date("GrA-1703", 4670, 70);
     R_Date("GrA-1708", 4640, 60);
    };
    Phase("Carrigdirty Rock")
    {
     R_Date("Beta-102086", 4710, 60);
     R_Date("GrA-27217", 4775, 40);
     R_Date("GrA-27232", 4770, 40);
    };
    Phase("Kilgreany Cave")
    {
     R_Date("Pta-2644", 4820, 60);
     R_Date("GrA-21499", 4790, 50);
     R_Date("BM-135", 4660, 75);
    };
    Phase("Lough Gur Site 10")
    {
     R_Date("GrN-16825", 4740, 60);
    };
   };
   Boundary("End Burials");
  };
 }
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 95.9 Aoverall 91.4				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Neolithic Burials																	
Boundary Start Burials							-3648	-3577	68.2	-3672	-3531	95.4					99.1
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3596	-3531	68.2	-3646	-3521	95.4		97.5			99.7
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3597	-3531	68.2	-3642	-3518	95.4		118.6			99.7
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3601	-3529	68.2	-3640	-3512	95.4		122.5			99.8
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3623	-3518	68.2	-3637	-3474	95.4		74.9			99.7
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3623	-3511	68.2	-3634	-3467	95.4		51.4			99.5
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3620	-3521	68.2	-3638	-3489	95.4		92.9			99.7
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3600	-3528	68.2	-3635	-3521	95.4		112.9			99.6
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3601	-3527	68.2	-3635	-3520	95.4		114.2			99.7
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3597	-3531	68.2	-3643	-3519	95.4		114.4			99.8
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3597	-3531	68.2	-3637	-3520	95.4		116			99.8
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3623	-3518	68.2	-3636	-3472	95.4		75.3			99.6
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3612	-3523	68.2	-3637	-3501	95.4		112.3			99.7
Boundary End Burials							-3584	-3492	68.2	-3630	-3399	95.4					98.1

Table C.3 Bayesian model for Early Neolithic burials in the southern region of Ireland

C.1.4. Bayesian model for Early Neolithic Fish-traps

```
Plot("Early Neolithic Field systems/Trackways/Fish-traps South of Ireland")
 {
  Sequence("Early Neolithic Field systems/Trackways/Fish-traps South of Ireland")
  {
   Boundary("Start Use");
   Phase("Carrigdirty Rock")
   {
    R_Date("Beta-102087", 4820, 50);
    R_Date("GrN-6520", 4820, 50);
   };
   Boundary("End Use");
  };
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 111.1 Aoverall 109.3				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic Field systems/Trackways/Fish-traps South of Ireland																	
Boundary Start Use							-3787	-3541	68.2	-4586	-3529	95.3					97.1
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3653	-3532	68.2	-3694	-3520	95.4		106.4			99.6
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3653	-3532	68.2	-3694	-3520	95.4		106.5			99.6
Boundary End Use							-3646	-3385	68.2	-3658	-2712	95.3					95.7

Table C.4 Bayesian model for Early Neolithic fish-traps in the southern region of Ireland

C.1.5. Bayesian model for start of Cereal Cultivation

```
Plot("Early Neolithic Cereal Cultivation South of Ireland")
 {
  Sequence("Cereal Cultivation South of Ireland")
  {
   Boundary("Start Cereal Cultivation");
   Phase("Cereal Cultivation")
   {
    Phase("Tankardstown South")
    {
     R_Date("UBA-14739", 5013, 31);
     R_Date("UBA-14737", 4958, 30);
     R_Date("UBA-14780", 4952, 38);
     R_Date("OxA-1476", 4890, 80);
     R_Date("UBA-14735", 4897, 32);
     R_Date("UBA-14734", 4895, 33);
     R_Date("UBA-14736", 4891, 31);
     R_Date("UBA-14738", 4890, 33);
     R_Date("OxA-1477", 4840, 45);
     R_Date("UBA-14742", 4947, 30);
     R_Date("UBA-14743", 4923, 33);
     R_Date("UBA-14740", 4899, 37);
    };
    Phase("Granny (site 27)")
    {
     R_Date("UBA-14683", 4926, 33);
     R_Date("UBA-14686", 4918, 32);
     R_Date("UBA-14684", 4911, 32);
     R_Date("UBA-14685", 4884, 32);
    };
    Phase("Kilkeasy")
    {
     R_Date("Poz-26459", 4840, 40);
     R_Date("Poz-25475", 4860, 35);
     R_Date("Poz-26461", 4820, 40);
    };
    Phase("Pepperhill")
    {
     R_Date("UBA-14791", 4926, 30);
     R_Date("UBA-14788", 4892, 28);
     R_Date("UBA-14789", 4860, 34);
     R_Date("UBA-14790", 4827, 28);
    };
    Phase("Marlfield")
    {
     R_Date("UBA-14792", 4800, 31);
     R_Date("UBA-14793", 4747, 32);
    };
    Phase("Shanagh (site 1)")
```

```
   {
    R_Date("UBA-21419", 4930, 45);
   };
   Phase("Ballinaspig More (site 5)")
   {
    R_Date("Beta-178211", 4860, 70);
   };
   Phase("Caherabbey Upper (site 185.1-4)")
   {
    R_Date("UBA-14411", 4822, 30);
    R_Date("UBA-14410", 4693, 43);
    R_Date("UBA-14408", 4856, 30);
    R_Date("UBA-14409", 4850, 29);
    R_Date("UBA-14406", 4849, 28);
    R_Date("UBA-14407", 4801, 28);
   };
   Phase("Danganbeg (site 10-5)")
   {
    R_Date("UBA-24492", 4788, 33);
   };
   Phase("Killsheelan")
   {
    R_Date("UBA-14670", 4839, 30);
    R_Date("UBA-14671", 4799, 33);
    R_Date("UBA-14672", 4786, 34);
    R_Date("UBA-14673", 4793, 36);
   };
   Phase("Newrath (site 35)")
   {
    R_Date("UB-6639", 4827, 39);
    R_Date("UBA-14798", 4809, 26);
    R_Date("UBA-14799", 4754, 27);
   };
   Phase("Suttonrath (site 206.1)")
   {
    R_Date("UBA-14809", 4789, 24);
    R_Date("UBA-14810", 4778, 26);
   };
  };
  Boundary("End Cereal Cultivation");
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 109.8 Aoverall 109.3				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Cereal Cultivation South of Ireland																	
Boundary Start Cereal Cultivation							-3730	-3702	68.2	-3749	-3689	95.4					98.2
Phase Cereal Cultivation																	
Phase Tankardstown South																	
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3726	-3671	68.2	-3734	-3661	95.4		46.9			99.3
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3716	-3663	68.2	-3727	-3655	95.4		81.1			99.5
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3712	-3662	68.2	-3726	-3650	95.4		96.9			99.6
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3708	-3636	68.2	-3723	-3539	95.4		126.7			99.8
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3694	-3651	68.2	-3707	-3642	95.4		107.5			99.9
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3693	-3651	68.2	-3707	-3641	95.4		107.5			99.9
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3694	-3649	68.2	-3706	-3641	95.4		104.8			99.9
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3694	-3648	68.2	-3706	-3640	95.4		106.1			99.9
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3694	-3544	68.3	-3705	-3536	95.4		104.3			99.7
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3712	-3663	68.2	-3726	-3652	95.4		100.1			99.8
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3701	-3661	68.2	-3716	-3646	95.4		118.7			99.8
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3696	-3651	68.2	-3710	-3640	95.4		112.5			99.9
Phase Granny (site 27)																	
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3702	-3661	68.2	-3716	-3646	95.4		119.1			99.8
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3699	-3659	68.2	-3713	-3646	95.4		116.6			99.9
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3697	-3657	68.2	-3711	-3645	95.4		113.4			99.8
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3694	-3645	68.2	-3704	-3639	95.4		103.9			99.8
Phase Kilkeasy																	
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3693	-3542	68.2	-3703	-3537	95.4		103.8			99.7
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3693	-3636	68.2	-3707	-3540	95.4		103.8			99.9
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3653	-3543	68.2	-3694	-3533	95.4		98.3			99.5

Phase Pepperhill																	
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3702	-3662	68.2	-3716	-3648	95.4		118.2			99.9
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3694	-3649	68.2	-3706	-3641	95.4		103.1			99.9
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3693	-3636	68.2	-3706	-3541	95.4		103.4			99.9
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3654	-3542	68.2	-3662	-3534	95.4		102.1			99.6
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3643	-3545	68.2	-3650	-3534	95.4		94.4			99.3
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3631	-3577	68.2	-3638	-3546	95.4		116.1			99.8
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3704	-3658	68.2	-3722	-3642	95.4		118.2			99.8
Phase Ballinaspig More (site 5)																	
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3706	-3573	68.2	-3714	-3538	95.4		121.3			99.8
Phase Caherabbey Upper (site 185.1-4)																	
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3652	-3542	68.1	-3661	-3533	95.4		98.5			99.4
R_Date UBA-14410	-3619	-3376	68.2	-3631	-3368	95.4	-3628	-3589	68.2	-3636	-3550	95.4		67			99.9
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3689	-3635	68.2	-3703	-3541	95.4		102.4			99.7
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3663	-3633	68.2	-3701	-3539	95.4		102.7			99.9
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3662	-3633	68.2	-3700	-3539	95.4		102.5			99.9
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3642	-3546	68.2	-3650	-3533	95.4		93			99.4
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3640	-3548	68.2	-3645	-3536	95.4		98.7			99.3
Phase Killsheelan																	
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3660	-3542	68.2	-3696	-3537	95.4		104.5			99.8
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3643	-3546	68.2	-3650	-3534	95.4		95.7			99.3
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3639	-3551	68.2	-3644	-3536	95.4		100			99.3
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3642	-3546	68.2	-3648	-3536	95.4		98.9			99.4
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3656	-3543	68.2	-3696	-3534	95.4		99.8			99.4
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3645	-3542	68.2	-3651	-3535	95.4		92.9			99.1

R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3632	-3569	68.2	-3637	-3546	95.4		110.7			99.8
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3637	-3535	68.2	-3641	-3523	95.4	-3639	-3547	68.2	-3644	-3534	95.4		93.8			99.3
R_Date UBA-14810	-3635	-3530	68.2	-3640	-3521	95.4	-3637	-3554	68.2	-3640	-3535	95.4		98.5			99.5
Boundary End Cereal Cultivation							-3555	-3525	68.2	-3581	-3520	95.4					97.4

Table C.5 Bayesian model for the start of cereal cultivation in the southern region of Ireland

C.1.6. Bayesian model for Early Neolithic Domesticates

```
Plot(“Early Neolithic Domesticates”)
 {
  Sequence("Domesticates")
  {
   Boundary("Start Domesticates");
   Phase("Ferriter's Cove Cattle Bone")
   {
    R_Date("OxA-3869", 5510, 70);
   };
   Boundary("End Ferriter's Cove");
   Boundary("Start Kilkeasy");
   Phase("Kilgreany Cave")
   {
    R_Date("OxA-4269", 5190, 80);
   };
   Boundary("End Kilkeasy");
   Boundary("Start Later Domesticates");
   Phase("Carrigdirty Rock 5")
   {
    R_Date("GrA-27216", 4775, 40);
   };
   Phase("Annagh Cave")
   {
    R_Date("GrA-1706", 4750, 60);
   };
   Boundary("End Domesticates");
  };
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 108.3 Aoverall 108.2				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Domesticates																	
Boundary Start Domesticates							-4513	-4284	68.2	-4829	-4085	95.5					97.9
Phase Ferriter's Cove Cattle Bone																	
R_Date OxA-3869	-4449	-4272	68.2	-4502	-4183	95.4	-4446	-4266	68.2	-4498	-4174	95.4		97.7			99.7
Boundary End Ferriter's Cove							-4391	-4180	68.2	-4451	-4024	95.4					99.7
Boundary Start Kilkeasy							-4226	-3973	68.2	-4322	-3834	95.4					99.7
Phase Kilgreany Cave																	
R_Date OxA-4269	-4224	-3816	68.1	-4234	-3798	95.4	-4070	-3814	68.2	-4225	-3797	95.4		104.6			99.8
Boundary End Kilkeasy							-4021	-3744	68.2	-4144	-3615	95.4					99.7
Boundary Start Later Domesticates							-3688	-3549	68.2	-3896	-3517	95.4					99.5
Phase Carrigdirty Rock 5																	
R_Date GrA-27216	-3636	-3526	68.2	-3646	-3382	95.4	-3639	-3552	68.2	-3647	-3518	95.4		105.1			99.6
Phase Annagh Cave																	
R_Date GrA-1706	-3635	-3385	68.2	-3645	-3373	95.4	-3610	-3512	68.2	-3638	-3380	95.4		109.1			99.5
Boundary End Domesticates							-3614	-3456	68.2	-3637	-3251	95.4					96.6

Table C.6 Bayesian model for Early domesticates in the southern region of Ireland

C.1.7. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 1

```
Plot("Model 1")
 {
  Sequence("Early Neolithic in the Southern Region of Ireland")
  {
   Boundary("Begin Early Neolithic");
   Phase("Early Neolithic")
   {
    Phase("Houses")
    {
     Phase("Ballinglanna North (site 3)")
     {
      After("TPQ Charcoal")
      {
       R_Date("UB-13145", 5010, 25);
       R_Date("UB-13146", 5007, 28);
      };
      R_Date("UBA-10499", 4936, 21);
     };
     Phase("Barnagore (site 3)")
     {
      After("TPQ Charcoal")
      {
       R_Date("Beta-171411", 4880, 70);
       R_Date("Beta-171412", 4950, 70);
      };
     };
     Phase("Caherdrinny (site 3)")
     {
      After("TPQ Charcoal")
      {
       R_Date("UBA-13289", 4877, 26);
       R_Date("UB-13284", 5138, 27);
       R_Date("UB-13286", 4926, 26);
       R_Date("UBA-13292", 5214, 27);
      };
     };
     Phase("Cloghers")
     {
      R_Date("Beta-134227", 4900, 40);
      R_Date("Beta-134226", 4850, 40);
     };
     Phase("Earlsrath")
     {
      After("TPQ Charcoal")
      {
       R_Date("UBA-14153", 4912, 30);
       R_Date("UBA-14160", 4917, 31);
```

```
  R_Date("UBA-14154", 5239, 31);
 };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
 };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
```

```
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
};
Phase("Tankardstown South")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-14713", 5105, 45);
  R_Date("GrN-15387", 4880, 110);
  R_Date("GrN-15386", 5005, 25);
  R_Date("GrN-16558", 5070, 20);
  R_Date("GrN-16557", 4995, 20);
 };
 R_Date("OxA-1476", 4890, 80);
 R_Date("UBA-14739", 5013, 31);
 R_Date("UBA-14780", 4952, 38);
 R_Date("UBA-14737", 4958, 30);
 R_Date("UBA-14734", 4895, 33);
 R_Date("UBA-14735", 4897, 32);
 R_Date("UBA-14738", 4890, 33);
 R_Date("UBA-14736", 4891, 31);
 R_Date("OxA-1477", 4840, 45);
 R_Date("UBA-14742", 4947, 30);
 R_Date("UBA-14743", 4923, 33);
 R_Date("UBA-14740", 4899, 37);
};
};
Phase("Ephemeral Sites")
{
Phase("Ballinaspig More (site 4)")
{
 After("TPQ Charcoal")
 {
  R_Date("Beta-178204", 5050, 50);
 };
};
Phase("Ballinaspig More (Site 5)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("Beta-178206", 5030, 70);
  R_Date("Beta-178210", 4990, 70);
 };
 R_Date("Beta-178211", 4860, 70);
```

```
};
Phase("Bawnfune (site 2) ")
{
 After("TPQ Charcoal")
 {
  R_Date("Poz-24934 ", 4880, 40);
 };
};
Phase("Caherabbey Upper (site 185.1-4)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("UB-7236", 5119, 38);
 };
 R_Date("UBA-14411", 4822, 30);
 R_Date("UBA-14408", 4856, 30);
 R_Date("UBA-14409", 4850, 29);
 R_Date("UBA-14406", 4849, 28);
 R_Date("UBA-14407", 4801, 28);
};
Phase("Curraghprevin (site 3)")
{
 After("TPQ Charcoal")
 {
  R_Date("Beta-201069", 4720, 80);
 };
};
Phase("Danganbeg (site 10-5)")
{
 R_Date("UBA-24492", 4788, 33);
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
```

```
 };
 Phase("Manor West")
 {
  After("TPQ Charcoal")
  {
   R_Date("QUB-7654", 5036, 40);
  };
 };
 Phase("Monadreela (site 7)")
 {
  After("TPQ Charcoal")
  {
   R_Date("UBA-13711", 5050, 32);
  };
 };
 Phase("Monadreela (site 9)")
 {
  After("TPQ Charcoal")
  {
   R_Date("UBA-13720", 4822, 32);
  };
 };
 Phase("Newrath (site 35)")
 {
  R_Date("UB-6639", 4827, 39);
  R_Date("UBA-14798", 4809, 26);
  R_Date("UB-6640", 4821, 38);
  R_Date("UBA-14799", 4754, 27);
 };
 Phase("Scart")
 {
  R_Date("Poz-26554", 4960, 40);
  R_Date("UBA-13996", 4861, 28);
  After("TPQ Oak Charcoal")
  {
   R_Date("UBA-13993", 5065, 31);
  };
 };
 Phase("Suttonrath (site 206.1)")
 {
  R_Date("UBA-14809", 4789, 28);
  R_Date("UBA-14810", 4778, 28);
  R_Date("UB-7208", 4744, 36);
 };
 Span("Duration of Occupation");
};
Phase("Burials")
{
 Phase("Annagh")
 {
```

```
    R_Date("GrA-1709", 4840, 60);
    R_Date("GrA-1707", 4810, 60);
    R_Date("GrA-1704", 4780, 60);
    R_Date("GrA-1703", 4670, 70);
    R_Date("GrA-1708", 4640, 60);
   };
   Phase("Carrigdirty Rock")
   {
    R_Date("Beta-102086", 4710, 60);
    R_Date("GrA-27217", 4775, 40);
    R_Date("GrA-27232", 4770, 40);
   };
   Phase("Kilgreany Cave")
   {
    R_Date("Pta-2644", 4820, 60);
    R_Date("GrA-21499", 4790, 50);
    R_Date("BM-135", 4660, 75);
   };
   Phase("Lough Gur Site 10")
   {
    R_Date("GrN-16825", 4740, 60);
   };
  };
  Phase("Fish-trap")
  {
   Phase("Carrigdirty Rock")
   {
    R_Date("Beta-102087", 4820, 50);
    R_Date("GrN-6520", 4820, 50);
   };
  };
  Before("TAQ Linkardstown Burials")
  {
   Phase("Jerpoint West")
   {
    R_Date("OxA-2680", 4770, 80);
   };
   Phase("Lisduggan North")
   {
    R_Date("OxA-2681",4585, 80);
   };
  };
  Span("Duration of the Early Neolithic");
 };
 Boundary("End Early Neolithic");
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 109 Aoverall 108.3				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic																	
Boundary Begin Early Neolithic							-3720	-3699	68.2	-3731	-3686	95.4					95.2
Phase Early Neolithic																	
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3907	-3715	68.2	-3938	-3708	95.4		99.1			99.9
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.4			99.9
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3707	-3663	68.2	-3711	-3656	95.4		116.7			99.4
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3762	-3545	68.1	-3896	-3532	95.4		103.6			99.9
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3796	-3651	68.2	-3943	-3638	95.4		100.2			99.9
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3701	-3638	95.4		99.2			99.9
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3983	-3846	68.2	-4033	-3808	95.3		99.7			99.9
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3651	95.4		99.3			99.9
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4041	-3981	68.2	-4054	-3963	95.4		99.6			99.9
Phase Cloghers																	
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3695	-3651	68.2	-3709	-3640	95.4		117			99.9
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3694	-3542	68.2	-3705	-3535	95.4		103.4			99.9
Phase Earlsrath																	
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4											
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3701	-3656	68.2	-3763	-3643	95.4		99.6			99.9

R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.5			99.9
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4054	-3981	68.2	-4227	-3970	95.4		99.8			99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3660	-3539	68.2	-3699	-3533	95.4		102.6			99.9
Phase Gortore (site 1)																	
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4											
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3928	-3655	95.4		99.8			99.9
Phase Granny (site 27)																	
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4											
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3703	-3650	68.2	-3766	-3638	95.4		99.8			99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.2	-3960	-3719	95.4		99.9			99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		100			99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3698	-3661	68.2	-3711	-3648	95.4		121.2			99.7
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3695	-3656	68.2	-3708	-3646	95.4		115.5			99.8
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3697	-3659	68.2	-3710	-3647	95.4		119			99.8
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3693	-3645	68.2	-3703	-3639	95.4		104.6			99.9
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3636	-3546	68.2	-3641	-3533	95.4		110			99.9
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3651	-3544	68.2	-3659	-3536	95.4		100			99.9
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3694	-3636	68.2	-3706	-3538	95.4		104.7			99.9
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3693	-3636	68.2	-3706	-3538	95.4		102.2			99.9
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3689	-3539	68.2	-3701	-3534	95.4		102.6			99.9
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3651	-3539	68.2	-3693	-3531	95.4		102.2			99.9
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3637	-3543	68.2	-3642	-3533	95.4		109.4			99.9
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3641	-3539	68.2	-3650	-3531	95.4		100.6			99.8
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3631	-3566	68.2	-3636	-3533	95.4		113.9			99.9
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											

R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3710	-3539	68.2	-3785	-3532	95.4		105.8			99.9
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3698	-3661	68.2	-3711	-3650	95.4		120.5			99.7
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3693	-3649	68.2	-3704	-3642	95.4		103.9			99.9
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3693	-3636	68.2	-3706	-3538	95.4		101.7			100
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3652	-3540	68.2	-3661	-3532	95.4		100.1			99.8
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3701	-3658	68.2	-3713	-3644	95.4		119.3			99.7
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3695	-3638	68.2	-3710	-3537	95.4		111.1			99.9
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3695	-3542	68.2	-3706	-3534	95.4		106.7			99.9
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3790	95.4		99.8			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3786	-3541	68.2	-3942	-3533	95.5		108.6			99.8
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.3			99.9
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3943	-3805	68.2	-3952	-3799	95.4		99.4			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3792	-3715	68.2	-3906	-3707	95.4		99.4			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3707	-3634	68.2	-3715	-3536	95.4		124.7			99.8
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3718	-3670	68.2	-3722	-3661	95.4		27.9			97.2
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3707	-3662	68.2	-3716	-3651	95.4		92.9			99.2
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3711	-3663	68.2	-3716	-3656	95.4		72.5			98.8
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3693	-3651	68.2	-3706	-3641	95.4		108.8			99.9
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3693	-3652	68.2	-3706	-3641	95.4		108.8			99.9
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3693	-3648	68.2	-3705	-3640	95.4		107.1			99.9
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3693	-3649	68.2	-3704	-3641	95.4		105.8			99.9
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3691	-3539	68.1	-3702	-3534	95.4		104.5			99.9
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3708	-3662	68.2	-3715	-3653	95.4		97.3			99.1
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3697	-3660	68.2	-3711	-3647	95.4		121.1			99.8
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3694	-3652	68.2	-3707	-3641	95.4		114.2			99.9
Phase Ephemeral Sites																	

Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3792	68.2	-3960	-3713	95.4		99.9			99.9
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3716	68.1	-3965	-3665	95.4		100			99.9
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3932	-3696	68.2	-3946	-3656	95.4		100			99.9
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3702	-3542	68.2	-3710	-3535	95.4		121.5			99.8
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3764	-3541	95.4		100.2			99.9
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.6			99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3651	-3539	68.2	-3660	-3532	95.4		99.9			99.8
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3691	-3635	68.2	-3702	-3539	95.4		99.9			99.9
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3663	-3633	68.2	-3700	-3537	95.4		99.5			100
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3661	-3633	68.2	-3699	-3537	95.4		99.3			99.9
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3641	-3539	68.2	-3649	-3532	95.4		99.3			99.8
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3632	-3562	68.2	-3657	-3526	95.4		99.8			99.8
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3639	-3540	68.2	-3645	-3532	95.4		103.3			99.8
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3770	-3637	95.4		100			99.9
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3657	-3541	68.2	-3695	-3535	95.4		100.6			99.9
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3641	-3539	68.2	-3650	-3531	95.4		101.4			99.9

R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3640	-3539	68.2	-3647	-3532	95.4		103.8			99.9
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3638	-3540	68.2	-3644	-3532	95.4		104.2			99.8
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3690	-3539	68.2	-3701	-3534	95.4		102.6			99.9
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		99.9			99.9
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3954	68.2	-4045	-3817	95.4		99.4			99.8
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3941	-3775	68.2	-3951	-3713	95.4		99.9			99.9
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.8			99.9
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3651	-3539	68.2	-3662	-3531	95.4		100			99.9
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3654	-3539	68.2	-3695	-3532	95.4		101.7			99.9
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3644	-3539	68.2	-3651	-3532	95.4		98.3			99.9
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3651	-3539	68.2	-3693	-3531	95.4		101.5			99.9
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3632	-3561	68.2	-3636	-3533	95.4		109.1			99.9
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3708	-3662	68.2	-3717	-3652	95.4		82.7			99.2
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3691	-3637	68.2	-3701	-3544	95.4		99.5			100
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.8			99.9
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3638	-3540	68.2	-3644	-3532	95.4		100.9			99.8
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3636	-3541	68.2	-3641	-3531	95.4		102.7			99.9

R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3631	-3566	68.2	-3636	-3534	95.4		114.5			99.9
Span Duration of Occupation							137	170	68.2	116	184	95.4					98.4
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3692	-3540	68.3	-3705	-3534	95.4		113.1			99.9
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3651	-3539	68.2	-3694	-3532	95.4		113			99.9
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3639	-3542	68.2	-3661	-3527	95.4		116.4			99.8
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3631	-3567	68.2	-3637	-3535	95.4		67.6			99.9
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3629	-3585	68.2	-3636	-3531	95.4		36.5			99.9
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3631	-3566	68.2	-3637	-3535	95.4		91.6			99.9
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3636	-3546	68.2	-3641	-3533	95.4		110.9			99.9
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3636	-3546	68.2	-3640	-3533	95.4		112.3			99.9
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3656	-3539	68.2	-3695	-3534	95.4		112.4			99.9
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3640	-3541	68.2	-3654	-3531	95.4		112			99.8
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3631	-3566	68.2	-3638	-3534	95.4		66.5			99.9
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3631	-3566	68.2	-3642	-3532	95.4		110.8			99.9
Phase Fish-trap																	
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3655	-3538	68.2	-3694	-3532	95.4		106.6			99.9
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3655	-3538	68.2	-3694	-3532	95.4		106.6			99.9
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3642	-3384	68.2	-3692	-3371	95.4		101.5			99.9
Phase Lisduggan North																	
R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3501	-3110	68.3	-3627	-3030	95.3		99.7			99.9
Span Duration of the Early Neolithic							157	183	68.2	138	198	95.4					96.7

Boundary End Early Neolithic					-3545	-3526	68.2	-3557	-3514	95.4					98.3

Table C.7 Bayesian mode for the start of the Early Neolithic in the southern region of Ireland – Model 1

C.1.8. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 1a (including Domesticates)

```
Plot("Model 1a")
 {
  Sequence("Early Neolithic in the Southern Region of Ireland ")
  {
   Boundary("Begin Early Neolithic");
   Phase("Early Neolithic")
   {
    Phase("Domesticates")
    {
     Phase("Ferriter's Cove")
     {
      R_Date("OxA-3869", 5510, 70);
     };
     Phase("Kilgreany Cave")
     {
      R_Date("OxA-4269", 5190, 80);
     };
     Phase("Carrigdirty Rock 5")
     {
      R_Date("GrA-27216", 4775, 40);
     };
     Phase("Annagh Cave")
     {
      R_Date("GrA-1706", 4750, 60);
     };
    };
    Phase("Houses")
    {
     Phase("Ballinglanna North (site 3)")
     {
      After("TPQ Charcoal")
      {
       R_Date("UB-13145", 5010, 25);
       R_Date("UB-13146", 5007, 28);
      };
      R_Date("UBA-10499", 4936, 21);
     };
     Phase("Barnagore (site 3)")
     {
      After("TPQ Charcoal")
      {
       R_Date("Beta-171411", 4880, 70);
       R_Date("Beta-171412", 4950, 70);
      };
     };
     Phase("Caherdrinny (site 3)")
     {
```

```
 After("TPQ Charcoal")
 {
  R_Date("UBA-13289", 4877, 26);
  R_Date("UB-13284", 5138, 27);
  R_Date("UB-13286", 4926, 26);
  R_Date("UBA-13292", 5214, 27);
 };
};
Phase("Cloghers")
{
 R_Date("Beta-134227", 4900, 40);
 R_Date("Beta-134226", 4850, 40);
};
Phase("Earlsrath")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-14153", 4912, 30);
  R_Date("UBA-14160", 4917, 31);
  R_Date("UBA-14154", 5239, 31);
 };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
```

```
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
 };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
};
Phase("Tankardstown South")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-14713", 5105, 45);
  R_Date("GrN-15387", 4880, 110);
  R_Date("GrN-15386", 5005, 25);
  R_Date("GrN-16558", 5070, 20);
  R_Date("GrN-16557", 4995, 20);
 };
 R_Date("OxA-1476", 4890, 80);
 R_Date("UBA-14739", 5013, 31);
 R_Date("UBA-14780", 4952, 38);
 R_Date("UBA-14737", 4958, 30);
 R_Date("UBA-14734", 4895, 33);
 R_Date("UBA-14735", 4897, 32);
 R_Date("UBA-14738", 4890, 33);
 R_Date("UBA-14736", 4891, 31);
 R_Date("OxA-1477", 4840, 45);
 R_Date("UBA-14742", 4947, 30);
 R_Date("UBA-14743", 4923, 33);
 R_Date("UBA-14740", 4899, 37);
```

```
 };
};
Phase("Ephemeral Sites")
{
 Phase("Ballinaspig More (site 4)")
 {
  After("TPQ Charcoal")
  {
   R_Date("Beta-178204", 5050, 50);
  };
 };
 Phase("Ballinaspig More (Site 5)")
 {
  After("TPQ Oak Charcoal")
  {
   R_Date("Beta-178206", 5030, 70);
   R_Date("Beta-178210", 4990, 70);
  };
  R_Date("Beta-178211", 4860, 70);
 };
 Phase("Bawnfune (site 2) ")
 {
  After("TPQ Charcoal")
  {
   R_Date("Poz-24934 ", 4880, 40);
  };
 };
 Phase("Caherabbey Upper (site 185.1-4)")
 {
  After("TPQ Oak Charcoal")
  {
   R_Date("UB-7236", 5119, 38);
  };
  R_Date("UBA-14411", 4822, 30);
  R_Date("UBA-14408", 4856, 30);
  R_Date("UBA-14409", 4850, 29);
  R_Date("UBA-14406", 4849, 28);
  R_Date("UBA-14407", 4801, 28);
 };
 Phase("Curraghprevin (site 3)")
 {
  After("TPQ Charcoal")
  {
   R_Date("Beta-201069", 4720, 80);
  };
 };
 Phase("Danganbeg (site 10-5)")
 {
  R_Date("UBA-24492", 4788, 33);
 };
```

```
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
 {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13720", 4822, 32);
 };
};
Phase("Newrath (site 35)")
{
 R_Date("UB-6639", 4827, 39);
 R_Date("UBA-14798", 4809, 26);
 R_Date("UB-6640", 4821, 38);
 R_Date("UBA-14799", 4754, 27);
};
Phase("Scart")
{
```

```
 R_Date("Poz-26554", 4960, 40);
 R_Date("UBA-13996", 4861, 28);
 After("TPQ Oak Charcoal")
 {
  R_Date("UBA-13993", 5065, 31);
 };
 };
 Phase("Suttonrath (site 206.1)")
 {
 R_Date("UBA-14809", 4789, 28);
 R_Date("UBA-14810", 4778, 28);
 R_Date("UB-7208", 4744, 36);
 };
 Span("Duration of Occupation");
};
Phase("Burials")
{
 Phase("Annagh")
 {
 R_Date("GrA-1709", 4840, 60);
 R_Date("GrA-1707", 4810, 60);
 R_Date("GrA-1704", 4780, 60);
 R_Date("GrA-1703", 4670, 70);
 R_Date("GrA-1708", 4640, 60);
 };
 Phase("Carrigdirty Rock")
 {
 R_Date("Beta-102086", 4710, 60);
 R_Date("GrA-27217", 4775, 40);
 R_Date("GrA-27232", 4770, 40);
 };
 Phase("Kilgreany Cave")
 {
 R_Date("Pta-2644", 4820, 60);
 R_Date("GrA-21499", 4790, 50);
 R_Date("BM-135", 4660, 75);
 };
 Phase("Lough Gur Site 10")
 {
 R_Date("GrN-16825", 4740, 60);
 };
};
Phase("Fish-trap")
{
 Phase("Carrigdirty Rock")
 {
 R_Date("Beta-102087", 4820, 50);
 R_Date("GrN-6520", 4820, 50);
 };
};
```

```
  Before("TAQ Linkardstown Burials")
  {
   Phase("Jerpoint West")
   {
    R_Date("OxA-2680", 4770, 80);
   };
   Phase("Lisduggan North")
   {
    R_Date("OxA-2681",4585, 80);
   };
  };
  Span("Duration of the Early Neolithic");
 };
 Boundary("End Early Neolithic");
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 43.5 Aoverall 46.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic																	
Boundary Begin Early Neolithic							-4005	-3972	68.2	-4020	-3964	95.4					97.9
Phase EN																	
Phase Domesticates																	
Phase Ferriter's Cove																	
R_Date OxA-3869	-4449	-4272	68.2	-4502	-4183	95.4	-3994	-3964	68.2	-4009	-3964	95.4		0.0			98.6
Phase Kilgreany Cave																	
R_Date OxA-4269	-4224	-3816	68.1	-4234	-3798	95.4	-3995	-3811	68.2	-4009	-3790	95.4		94.7			99.7
Phase Carrigdirty Rock 5																	
R_Date GrA-27216	-3636	-3526	68.2	-3646	-3382	95.4	-3635	-3530	68.2	-3641	-3521	95.4		110.2			99.9
Phase Annagh Cave																	
R_Date GrA-1706	-3635	-3385	68.2	-3645	-3373	95.4	-3632	-3530	68.2	-3646	-3511	95.4		113.8			99.8
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.2	-3938	-3708	95.4		99.2			99.9
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.3			99.8
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3713	-3660	68.2	-3766	-3656	95.4		98.7			99.9
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3762	-3540	68.2	-3897	-3522	95.4		102.2			99.8
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3796	-3651	68.2	-3943	-3638	95.4		100			99.7
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3701	-3638	95.4		99			99.9

R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3982	-3846	68.2	-4033	-3808	95.5		99.4			99.9
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3650	95.4		99.5			99.9
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4040	-3981	68.2	-4055	-3963	95.4		99.5			99.7
Phase Cloghers																	
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3704	-3648	68.2	-3768	-3637	95.4		99.8			99.8
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3695	-3540	68.2	-3709	-3528	95.4		99.3			99.8
Phase Earlsrath																	
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4											
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.6			99.8
R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.5			99.8
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4054	-3981	68.2	-4227	-3971	95.4		99.9			99.8
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3659	-3535	68.2	-3701	-3526	95.4		99.9			99.7
Phase Gortore (site 1)																	
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4											
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3929	-3655	95.4		99.9			99.9
Phase Granny (site 27)																	
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4											
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3703	-3650	68.2	-3766	-3638	95.4		99.7			99.8
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3941	-3797	68.2	-3960	-3719	95.4		99.9			99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		99.9			99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3713	-3653	68.2	-3773	-3648	95.4		99.6			99.8
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3703	-3655	68.2	-3765	-3642	95.4		99.6			99.9
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3708	-3655	68.2	-3766	-3645	95.4		99.5			99.8
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3695	-3645	68.2	-3714	-3634	95.4		99.4			99.8
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3636	-3530	68.2	-3641	-3521	95.4		109.4			99.9
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3651	-3542	68.2	-3658	-3534	95.4		97.3			99.8
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3695	-3635	68.2	-3713	-3530	95.4		99.2			99.8

R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3694	-3636	68.2	-3708	-3536	95.4		98.8			99.9
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3690	-3536	68.2	-3703	-3528	95.4		99.4			99.8
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3651	-3535	68.2	-3694	-3522	95.4		101.1			99.9
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3637	-3531	68.2	-3642	-3522	95.4		108.8			99.9
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3641	-3534	68.2	-3649	-3524	95.4		100.2			99.9
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3631	-3526	68.2	-3635	-3518	95.4		113			100
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											
R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3710	-3533	68.2	-3785	-3522	95.4		104.2			99.9
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3712	-3655	68.2	-3767	-3650	95.4		99.4			99.8
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3695	-3649	68.2	-3709	-3640	95.4		99.7			99.9
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3694	-3636	68.2	-3708	-3536	95.4		98.5			99.9
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3652	-3538	68.2	-3661	-3528	95.4		98.1			99.9
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3761	-3654	68.2	-3796	-3640	95.4		99.9			99.8
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3703	-3636	68.2	-3766	-3532	95.4		99.8			99.9
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3696	-3539	68.2	-3714	-3524	95.4		100			99.8
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3985	-3790	95.4		99.7			99.7
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3786	-3532	68.2	-3942	-3519	95.4		107.5			99.6
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			99.8
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.4			99.9
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3791	-3715	68.2	-3906	-3707	95.4		99.4			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3775	-3541	68.2	-3932	-3523	95.4		102.7			99.7
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3915	-3715	68.2	-3943	-3707	95.4		99.4			99.9
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3772	-3670	68.2	-3891	-3650	95.4		99.9			99.8
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3772	-3701	68.2	-3792	-3659	95.4		99.8			99.7

R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3696	-3651	68.2	-3761	-3637	95.4		99.7			99.8
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3696	-3651	68.2	-3761	-3637	95.5		99.6			99.8
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3696	-3647	68.2	-3761	-3636	95.4		99.7			99.8
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3696	-3648	68.2	-3757	-3637	95.4		99.7			99.8
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3692	-3536	68.2	-3706	-3525	95.4		100.4			99.8
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3765	-3667	68.2	-3782	-3656	95.4		99.7			99.8
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3713	-3652	68.2	-3771	-3647	95.4		99.7			99.8
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3701	-3650	68.2	-3765	-3638	95.4		99.7			99.9
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3792	68.2	-3960	-3713	95.4		100			99.8
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3719	68.1	-3966	-3664	95.4		100			99.7
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3933	-3696	68.2	-3946	-3656	95.4		99.9			99.8
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3710	-3533	68.2	-3785	-3522	95.4		104.3			99.8
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3764	-3539	95.4		99.6			99.9
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3971	-3811	68.2	-3987	-3798	95.4		99.6			99.7
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3651	-3536	68.2	-3659	-3527	95.4		98.4			99.9
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3692	-3635	68.2	-3705	-3537	95.4		98.3			99.9
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3663	-3544	68.2	-3701	-3536	95.4		97.6			99.9
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3662	-3544	68.2	-3700	-3536	95.4		97.3			99.9
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3640	-3535	68.2	-3647	-3526	95.4		99.2			99.9
Phase Curraghprevin (site 3)																	

After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3632	-3526	68.2	-3654	-3501	95.4		101.7			99.8
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3638	-3532	68.2	-3644	-3523	95.4		102.9			99.9
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3771	-3637	95.4		99.7			99.8
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3657	-3539	68.2	-3696	-3532	95.4		98			99.9
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3641	-3533	68.2	-3649	-3524	95.4		101.2			99.8
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3640	-3531	68.2	-3647	-3523	95.4		103.5			99.9
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3638	-3532	68.2	-3644	-3523	95.4		103.9			99.9
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3692	-3536	68.2	-3704	-3528	95.4		98.9			99.8
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		99.8			99.8
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3954	68.2	-4045	-3818	95.4		98.9			99.7
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3941	-3776	68.2	-3951	-3713	95.4		99.8			99.9
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.9			99.9
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3651	-3536	68.2	-3661	-3525	95.4		98.9			99.9
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3654	-3536	68.2	-3695	-3525	95.4		100.1			99.9
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3643	-3536	68.2	-3651	-3527	95.4		97.9			99.9
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3651	-3535	68.2	-3693	-3523	95.3		100.4			99.8

R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3632	-3526	68.3	-3635	-3521	95.4		108.8			99.9
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3783	-3695	68.2	-3909	-3651	95.4		100			99.8
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3692	-3637	68.2	-3703	-3542	95.4		98			99.9
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.8			99.9
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3637	-3534	68.2	-3643	-3524	95.4		100.8			99.9
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3635	-3531	68.2	-3640	-3523	95.4		102.4			99.9
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3631	-3526	68.2	-3636	-3517	95.4		113.5			100
Span Duration of Occupation							163	248	68.2	132	393	95.4					99.9
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3695	-3534	68.2	-3761	-3519	95.4		104.3			99.8
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3651	-3529	68.2	-3697	-3519	95.4		110.3			99.8
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3638	-3530	68.2	-3661	-3511	95.4		115.5			99.8
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3631	-3516	68.2	-3636	-3505	95.4		73.3			99.8
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3629	-3509	68.2	-3635	-3496	95.4		47.4			99.7
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3631	-3521	68.2	-3637	-3510	95.4		93.9			99.8
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3635	-3530	68.2	-3641	-3521	95.4		110.2			99.9
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3634	-3530	68.2	-3640	-3521	95.4		111.6			99.9
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3656	-3529	68.2	-3704	-3519	95.4		108.3			99.7
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3640	-3530	68.2	-3655	-3518	95.4		111.2			99.8
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3631	-3515	68.2	-3637	-3504	95.4		72.7			99.6
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3631	-3530	68.2	-3642	-3511	95.4		110.8			99.9
Phase Fish-trap																	

Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3654	-3531	68.2	-3696	-3522	95.4		104.7			99.8
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3654	-3531	68.2	-3695	-3523	95.4		104.7			99.8
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3642	-3384	68.2	-3694	-3370	95.4		99.9			99.7
Phase Lisduggan North																	
R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3502	-3109	68.2	-3627	-3029	95.3		99.7			99.7
Span Duration of the Early Neolithic							443	481	68.2	431	503	95.4					99.3
Boundary End Early Neolithic							-3531	-3502	68.2	-3539	-3484	95.4					98.6

Table C.8 Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 1a (including Domesticates)

C.1.9. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 2

```
Plot(“Model 2”)
 {
  Sequence(“Early Neolithic”)
  {
   Boundary("Start Early Neolithic");
   Phase("Houses")
   {
    Phase("Ballinglanna North (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("UB-13145", 5010, 25);
      R_Date("UB-13146", 5007, 28);
     };
     R_Date("UBA-10499", 4936, 21);
    };
    Phase("Barnagore (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("Beta-171411", 4880, 70);
      R_Date("Beta-171412", 4950, 70);
     };
    };
    Phase("Caherdrinny (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("UBA-13289", 4877, 26);
      R_Date("UB-13284", 5138, 27);
      R_Date("UB-13286", 4926, 26);
      R_Date("UBA-13292", 5214, 27);
     };
```

```
};
Phase("Cloghers")
{
 R_Date("Beta-134227", 4900, 40);
 R_Date("Beta-134226", 4850, 40);
};
Phase("Earlsrath")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-14153", 4912, 30);
  R_Date("UBA-14160", 4917, 31);
  R_Date("UBA-14154", 5239, 31);
 };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
```

```
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
 };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
```

```
 };
 Phase("Tankardstown South")
 {
  After("TPQ Charcoal")
  {
   R_Date("GrN-14713", 5105, 45);
   R_Date("GrN-15387", 4880, 110);
   R_Date("GrN-15386", 5005, 25);
   R_Date("GrN-16558", 5070, 20);
   R_Date("GrN-16557", 4995, 20);
  };
  R_Date("OxA-1476", 4890, 80);
  R_Date("UBA-14739", 5013, 31);
  R_Date("UBA-14780", 4952, 38);
  R_Date("UBA-14737", 4958, 30);
  R_Date("UBA-14734", 4895, 33);
  R_Date("UBA-14735", 4897, 32);
  R_Date("UBA-14738", 4890, 33);
  R_Date("UBA-14736", 4891, 31);
  R_Date("OxA-1477", 4840, 45);
  R_Date("UBA-14742", 4947, 30);
  R_Date("UBA-14743", 4923, 33);
  R_Date("UBA-14740", 4899, 37);
 };
 Span("Duration House South of Ireland");
};
Boundary("End Houses");
Boundary("Start Ephemeral/Burial/Fish-trap");
Phase("Ephemeral Sites")
{
 Phase("Ballinaspig More (site 4)")
 {
  After("TPQ Charcoal")
  {
   R_Date("Beta-178204", 5050, 50);
```

```
 };
};
Phase("Ballinaspig More (Site 5)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("Beta-178206", 5030, 70);
  R_Date("Beta-178210", 4990, 70);
 };
 R_Date("Beta-178211", 4860, 70);
};
Phase("Bawnfune (site 2) ")
{
 After("TPQ Charcoal")
 {
  R_Date("Poz-24934 ", 4880, 40);
 };
};
Phase("Caherabbey Upper (site 185.1-4)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("UB-7236", 5119, 38);
 };
 R_Date("UBA-14411", 4822, 30);
 R_Date("UBA-14408", 4856, 30);
 R_Date("UBA-14409", 4850, 29);
 R_Date("UBA-14406", 4849, 28);
 R_Date("UBA-14407", 4801, 28);
};
Phase("Curraghprevin (site 3)")
{
 After("TPQ Charcoal")
 {
  R_Date("Beta-201069", 4720, 80);
```

```
 };
};
Phase("Danganbeg (site 10-5)")
{
 R_Date("UBA-24492", 4788, 33);
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
  {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
  {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
  {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
```

```
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13720", 4822, 32);
 };
};
Phase("Newrath (site 35)")
{
 R_Date("UB-6639", 4827, 39);
 R_Date("UBA-14798", 4809, 26);
 R_Date("UB-6640", 4821, 38);
 R_Date("UBA-14799", 4754, 27);
};
Phase("Scart")
{
 R_Date("Poz-26554", 4960, 40);
 R_Date("UBA-13996", 4861, 28);
 After("TPQ Oak Charcoal")
 {
  R_Date("UBA-13993", 5065, 31);
 };
};
Phase("Suttonrath (site 206.1)")
{
 R_Date("UBA-14809", 4789, 28);
 R_Date("UBA-14810", 4778, 28);
 R_Date("UB-7208", 4744, 36);
};
Span("Duration of Occupation");
```

```
};
Phase("Burials")
{
 Phase("Annagh")
 {
  R_Date("GrA-1709", 4840, 60);
  R_Date("GrA-1707", 4810, 60);
  R_Date("GrA-1704", 4780, 60);
  R_Date("GrA-1703", 4670, 70);
  R_Date("GrA-1708", 4640, 60);
 };
 Phase("Carrigdirty Rock")
 {
  R_Date("Beta-102086", 4710, 60);
  R_Date("GrA-27217", 4775, 40);
  R_Date("GrA-27232", 4770, 40);
 };
 Phase("Kilgreany Cave")
 {
  R_Date("Pta-2644", 4820, 60);
  R_Date("GrA-21499", 4790, 50);
  R_Date("BM-135", 4660, 75);
 };
 Phase("Lough Gur Site 10")
 {
  R_Date("GrN-16825", 4740, 60);
 };
};
Phase("Fish-trap")
{
 Phase("Carrigdirty Rock")
 {
  R_Date("Beta-102087", 4820, 50);
  R_Date("GrN-6520", 4820, 50);
 };
```

```
  };
  Before("TAQ Linkardstown Burials")
  {
   Phase("Jerpoint West")
   {
    R_Date("OxA-2680", 4770, 80);
   };
   Phase("Lisduggan North")
   {
    R_Date("OxA-2681",4585, 80);
   };
  };
  Span("Duration");
  Boundary("End Early Neolithic");
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 31.6 Aoverall 42.5				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic																	
Boundary Start Early Neolithic							-3705	-3668	68.2	-3720	-3662	95.4					29.9
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.2	-3938	-3708	95.4		99.2			99.9
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.2			99.9
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3682	-3657	68.2	-3705	-3652	95.4		105.9			75.4
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3759	-3637	68.2	-3905	-3628	95.4		115			97.8
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3792	-3653	68.2	-3942	-3639	95.4		102			99.8
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3700	-3639	95.4		100.1			99.7
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3982	-3847	68.2	-4033	-3808	95.4		99.3			99.9
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3651	95.4		99.3			100
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4041	-3981	68.2	-4054	-3963	95.4		99.7			99.9
Phase Cloghers																	
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3676	-3646	68.2	-3698	-3639	95.4		119.5			83.6
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3664	-3636	68.2	-3693	-3632	95.4		134.5			89
Phase Earlsrath																	
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4											
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.8			99.9
R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.7			99.9

R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4143	-3981	68.2	-4227	-3970	95.4		99.9			99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3658	-3635	68.2	-3688	-3630	95.4		128.1			82.4
Phase Gortore (site 1)																	
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4											
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3928	-3655	95.4		100			100
Phase Granny (site 27)																	
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4											
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3702	-3651	68.2	-3765	-3639	95.4		100.8			99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.1	-3960	-3719	95.4		99.9			99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.1	-3957	-3715	95.4		100			99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3682	-3652	68.2	-3701	-3646	95.4		116.3			78.6
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3679	-3650	68.2	-3700	-3643	95.4		114			80.7
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3681	-3651	68.2	-3701	-3644	95.4		116			79.6
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3674	-3642	68.2	-3695	-3638	95.4		111.1			88.3
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3646	-3631	68.2	-3657	-3623	95.4		66.9			27.9
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3650	-3636	68.2	-3660	-3631	95.4		124.6			81.1
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3668	-3638	68.2	-3693	-3634	95.4		130.5			90.4
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3665	-3638	68.2	-3691	-3635	95.4		124.4			92.2
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3659	-3636	68.2	-3690	-3631	95.4		132.4			85.2
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3654	-3634	68.2	-3688	-3627	95.4		108			70.1
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3646	-3631	68.2	-3659	-3623	95.4		68.8			31.7
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3647	-3632	68.2	-3656	-3626	95.4		80.3			39.2
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3643	-3628	68.2	-3651	-3622	95.4		53.9			10.9
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											
R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3709	-3635	68.2	-3797	-3627	95.4		115.5			95.2

R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3681	-3653	68.2	-3703	-3647	95.4		115.6			78.2
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3675	-3646	68.2	-3696	-3641	95.4		107			86
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3664	-3638	68.2	-3691	-3635	95.4		123.1			92.4
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3650	-3636	68.2	-3662	-3628	95.4		124.7			74.9
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3680	-3650	68.2	-3703	-3641	95.4		114.3			80.1
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3671	-3639	68.2	-3695	-3634	95.4		134.6			87.8
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3667	-3636	68.2	-3695	-3631	95.4		138.6			86.8
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3791	95.4		99.8			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3785	-3636	68.2	-3943	-3629	95.4		112.2			97.3
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			99.9
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.5			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3791	-3715	68.2	-3906	-3707	95.4		99.5			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3675	-3641	68.2	-3701	-3632	95.4		154.1			83.3
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3683	-3658	68.2	-3716	-3655	95.4		8.3			71.8
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3682	-3654	68.2	-3707	-3647	95.4		81			77.3
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3682	-3656	68.2	-3710	-3651	95.4		55.4			75.4
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3676	-3646	68.2	-3696	-3640	95.4		111.4			84.8
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3676	-3646	68.2	-3696	-3641	95.4		110.5			83.9
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3675	-3644	68.2	-3696	-3639	95.4		111.3			86.1
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3674	-3645	68.2	-3695	-3640	95.4		109.4			86
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3661	-3635	68.2	-3691	-3631	95.4		132.7			84.4
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3681	-3656	68.2	-3706	-3650	95.4		84.4			76.1
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3682	-3652	68.2	-3701	-3645	95.4		116.9			79
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3676	-3646	68.2	-3697	-3640	95.4		116.2			84
Span Duration House South of Ireland							28	73	68.2	19	89	95.4					13.3
Boundary End Houses							-3642	-3625	68.2	-3646	-3618	95.4					7

Boundary Start Ephemeral/Burial/Fish-trap							-3642	-3544	68.2	-3646	-3541	95.4					3
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3792	68.2	-3961	-3713	95.4		100			99.9
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3716	68.3	-3965	-3665	95.4		100			99.9
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3932	-3696	68.2	-3946	-3656	95.4		100.1			99.9
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3639	-3541	68.2	-3644	-3537	95.4		124.4			3.3
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3763	-3546	95.5		102			99.6
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.7			99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3639	-3541	68.2	-3643	-3537	95.4		139.6			3.4
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3639	-3541	68.2	-3643	-3538	95.4		44.1			3
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3639	-3541	68.2	-3643	-3538	95.4		53.9			3
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3639	-3541	68.2	-3643	-3538	95.4		52.1			3
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3639	-3541	68.2	-3643	-3537	95.4		139.9			3.7
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3651	-3564	68.2	-3697	-3541	95.4		78.8			16.9
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3639	-3541	68.2	-3642	-3537	95.4		125.3			3.7
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3705	-3647	68.2	-3768	-3638	95.4		100.5			99.9

R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3639	-3541	68.2	-3643	-3537	95.4		91.6			3.2
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3639	-3541	68.2	-3643	-3537	95.4		139.3			3.6
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3639	-3541	68.2	-3643	-3537	95.4		133.5			3.6
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3639	-3541	68.2	-3642	-3537	95.4		123.1			3.7
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3639	-3541	68.2	-3643	-3537	95.4		118.4			3.3
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		99.9			99.9
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3953	68.2	-4045	-3818	95.4		99.5			99.9
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3941	-3776	68.2	-3951	-3713	95.4		99.9			99.9
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.9			99.9
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3655	-3543	68.2	-3692	-3538	95.4		107.3			66.8
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3639	-3541	68.2	-3644	-3537	95.4		146.6			3.4
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3639	-3541	68.2	-3643	-3537	95.4		143.8			3.6
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3639	-3541	68.2	-3644	-3537	95.4		150.3			3.4
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3638	-3541	68.2	-3641	-3537	95.4		53.2			3.8
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3640	-3541	68.2	-3643	-3539	95.4		0.3			2.5
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3639	-3541	68.2	-3643	-3538	95.4		29.8			2.8
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.8			100
Phase Suttonrath (site 206.1)																	

R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3639	-3541	68.2	-3641	-3537	95.4		124.1			3.7
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3639	-3541	68.2	-3641	-3537	95.4		104.1			3.8
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3638	-3541	68.2	-3641	-3537	95.4		55.9			3.7
Span Duration of Occupation							0	10	68.2	0	17	95.4					88.5
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3634	-3535	68.2	-3640	-3529	95.4		124.6			3.1
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3634	-3535	68.2	-3640	-3529	95.4		145.4			3.2
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3634	-3535	68.2	-3640	-3528	95.4		134.4			3.2
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3634	-3535	68.2	-3640	-3528	95.4		39.2			3.3
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3634	-3535	68.2	-3640	-3528	95.4		12.1			3.3
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3634	-3535	68.2	-3640	-3528	95.4		62.1			3.3
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3634	-3535	68.2	-3640	-3529	95.4		121.4			3.2
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3634	-3535	68.2	-3640	-3528	95.4		117.4			3.2
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3634	-3535	68.2	-3640	-3529	95.4		143.5			3.2
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3634	-3535	68.2	-3640	-3529	95.4		135.8			3.2
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3634	-3535	68.2	-3640	-3528	95.4		39.5			3.3
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3634	-3535	68.2	-3640	-3528	95.4		97.4			3.2
Phase Fish-trap																	
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3634	-3531	68.2	-3638	-3526	95.4		120.1			3.4
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3634	-3531	68.2	-3638	-3526	95.4		120.1			3.4
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3541	-3376	68.2	-3626	-3368	95.4		91.4			51.5
Phase Lisduggan North																	

R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3501	-3111	68.2	-3526	-3030	95.4		102.1			99.1
Span Duration							35	176	68.2	29	191	95.4					3
Boundary End Early Neolithic							-3634	-3530	68.2	-3638	-3524	95.4					3.4

Table C.9 Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 2

C.1.10. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 2a (including Domesticates)

```
Plot(“Model 2a”)
 {
  Sequence(“Early Neolithic”)
  {
   Boundary("Start Early Neolithic");
   Phase("Domesticates")
   {
    Phase("Ferriter's Cove")
    {
     R_Date("OxA-3869", 5510, 70);
    };
    Phase("Kilgreany Cave")
    {
     R_Date("OxA-4269", 5190, 80);
    };
    Phase("Carrigdirty Rock 5")
    {
     R_Date("GrA-27216", 4775, 40);
    };
    Phase("Annagh Cave")
    {
     R_Date("GrA-1706", 4750, 60);
    };
   };
   Phase("Houses")
   {
    Phase("Ballinglanna North (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("UB-13145", 5010, 25);
      R_Date("UB-13146", 5007, 28);
     };
     R_Date("UBA-10499", 4936, 21);
    };
    Phase("Barnagore (site 3)")
    {
     After("TPQ Charcoal")
     {
      R_Date("Beta-171411", 4880, 70);
      R_Date("Beta-171412", 4950, 70);
     };
    };
    Phase("Caherdrinny (site 3)")
    {
     After("TPQ Charcoal")
     {
```

```
  R_Date("UBA-13289", 4877, 26);
  R_Date("UB-13284", 5138, 27);
  R_Date("UB-13286", 4926, 26);
  R_Date("UBA-13292", 5214, 27);
 };
};
Phase("Cloghers")
{
 R_Date("Beta-134227", 4900, 40);
 R_Date("Beta-134226", 4850, 40);
};
Phase("Earlsrath")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-14153", 4912, 30);
  R_Date("UBA-14160", 4917, 31);
  R_Date("UBA-14154", 5239, 31);
 };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
```

```
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
 };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
};
Phase("Tankardstown South")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-14713", 5105, 45);
  R_Date("GrN-15387", 4880, 110);
  R_Date("GrN-15386", 5005, 25);
  R_Date("GrN-16558", 5070, 20);
  R_Date("GrN-16557", 4995, 20);
 };
 R_Date("OxA-1476", 4890, 80);
 R_Date("UBA-14739", 5013, 31);
 R_Date("UBA-14780", 4952, 38);
 R_Date("UBA-14737", 4958, 30);
 R_Date("UBA-14734", 4895, 33);
 R_Date("UBA-14735", 4897, 32);
 R_Date("UBA-14738", 4890, 33);
 R_Date("UBA-14736", 4891, 31);
 R_Date("OxA-1477", 4840, 45);
 R_Date("UBA-14742", 4947, 30);
 R_Date("UBA-14743", 4923, 33);
 R_Date("UBA-14740", 4899, 37);
};
Span("Duration House South of Ireland");
```

```
};
Boundary("End Houses");
Boundary("Start Ephemeral/Burial/Fish-trap");
Phase("Ephemeral Sites")
{
 Phase("Ballinaspig More (site 4)")
 {
  After("TPQ Charcoal")
  {
   R_Date("Beta-178204", 5050, 50);
  };
 };
 Phase("Ballinaspig More (Site 5)")
 {
  After("TPQ Oak Charcoal")
  {
   R_Date("Beta-178206", 5030, 70);
   R_Date("Beta-178210", 4990, 70);
  };
  R_Date("Beta-178211", 4860, 70);
 };
 Phase("Bawnfune (site 2) ")
 {
  After("TPQ Charcoal")
  {
   R_Date("Poz-24934 ", 4880, 40);
  };
 };
 Phase("Caherabbey Upper (site 185.1-4)")
 {
  After("TPQ Oak Charcoal")
  {
   R_Date("UB-7236", 5119, 38);
  };
  R_Date("UBA-14411", 4822, 30);
  R_Date("UBA-14408", 4856, 30);
  R_Date("UBA-14409", 4850, 29);
  R_Date("UBA-14406", 4849, 28);
  R_Date("UBA-14407", 4801, 28);
 };
 Phase("Curraghprevin (site 3)")
 {
  After("TPQ Charcoal")
  {
   R_Date("Beta-201069", 4720, 80);
  };
 };
 Phase("Danganbeg (site 10-5)")
 {
  R_Date("UBA-24492", 4788, 33);
```

```
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
 {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13720", 4822, 32);
 };
};
Phase("Newrath (site 35)")
{
 R_Date("UB-6639", 4827, 39);
 R_Date("UBA-14798", 4809, 26);
 R_Date("UB-6640", 4821, 38);
 R_Date("UBA-14799", 4754, 27);
};
Phase("Scart")
```

```
  {
  R_Date("Poz-26554", 4960, 40);
  R_Date("UBA-13996", 4861, 28);
  After("TPQ Oak Charcoal")
   {
   R_Date("UBA-13993", 5065, 31);
   };
  };
 Phase("Suttonrath (site 206.1)")
  {
  R_Date("UBA-14809", 4789, 28);
  R_Date("UBA-14810", 4778, 28);
  R_Date("UB-7208", 4744, 36);
  };
 Span("Duration of Occupation");
};
Phase("Burials")
{
 Phase("Annagh")
  {
  R_Date("GrA-1709", 4840, 60);
  R_Date("GrA-1707", 4810, 60);
  R_Date("GrA-1704", 4780, 60);
  R_Date("GrA-1703", 4670, 70);
  R_Date("GrA-1708", 4640, 60);
  };
 Phase("Carrigdirty Rock")
  {
  R_Date("Beta-102086", 4710, 60);
  R_Date("GrA-27217", 4775, 40);
  R_Date("GrA-27232", 4770, 40);
  };
 Phase("Kilgreany Cave")
  {
  R_Date("Pta-2644", 4820, 60);
  R_Date("GrA-21499", 4790, 50);
  R_Date("BM-135", 4660, 75);
  };
 Phase("Lough Gur Site 10")
  {
  R_Date("GrN-16825", 4740, 60);
  };
};
Phase("Fish-trap")
{
 Phase("Carrigdirty Rock")
  {
  R_Date("Beta-102087", 4820, 50);
  R_Date("GrN-6520", 4820, 50);
  };
```

```
  };
  Before("TAQ Linkardstown Burials")
  {
   Phase("Jerpoint West")
   {
    R_Date("OxA-2680", 4770, 80);
   };
   Phase("Lisduggan North")
   {
    R_Date("OxA-2681",4585, 80);
   };
  };
  Span("Duration");
  Boundary("End Early Neolithic");
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 3.8 Aoverall 4.2				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic																	
Boundary Start Early Neolithic							-4026	-3981	68.2	-4085	-3969	95.4					99.5
Phase Domesticates																	
Phase Ferriter's Cove																	
R_Date OxA-3869	-4449	-4272	68.2	-4502	-4183	95.4	-4012	-3978	68.2	-4076	-3964	95.4		0.3			99.6
Phase Kilgreany Cave																	
R_Date OxA-4269	-4224	-3816	68.1	-4234	-3798	95.4	-4010	-3812	68.2	-4035	-3795	95.4		106.3			99.9
Phase Carrigdirty Rock 5																	
R_Date GrA-27216	-3636	-3526	68.2	-3646	-3382	95.4	-3768	-3748	68.2	-3779	-3740	95.4		0.0			100
Phase Annagh Cave																	
R_Date GrA-1706	-3635	-3385	68.2	-3645	-3373	95.4	-3774	-3746	68.2	-3796	-3729	95.4		0.2			99.9
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.3	-3938	-3708	95.4		99.2			100
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.3			99.9
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3712	-3662	68.2	-3754	-3656	95.4		104.6			100
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3762	-3633	68.2	-3900	-3551	95.4		107.2			99.9
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3794	-3652	68.2	-3942	-3638	95.4		101			99.9
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3700	-3639	95.4		99.6			100
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3982	-3847	68.2	-4033	-3808	95.4		99.5			100

R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3650	95.4		99.3		100
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4041	-3981	68.2	-4055	-3963	95.4		99.6		99.9
Phase Cloghers																
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3701	-3651	68.2	-3750	-3638	95.4		106.3		100
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3694	-3633	68.2	-3709	-3550	95.4		108.5		99.8
Phase Earlsrath																
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4										
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.7		99.9
R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.7		100
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4054	-3981	68.2	-4227	-3970	95.3		99.8		99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3694	-3568	68.2	-3703	-3550	95.4		101.9		99.1
Phase Gortore (site 1)																
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4										
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3929	-3655	95.4		99.9		100
Phase Granny (site 27)																
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4										
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3702	-3650	68.2	-3765	-3638	95.4		100.4		99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3796	68.2	-3960	-3718	95.4		99.9		99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		99.9		99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3710	-3656	68.2	-3752	-3650	95.4		107		100
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3701	-3656	68.2	-3751	-3642	95.4		104.4		100
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3751	-3646	95.4		105.5		100
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3695	-3645	68.2	-3709	-3637	95.4		101.6		100
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3640	-3567	68.2	-3646	-3555	95.4		100.8		95.5
Phase Kilkeasy																
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4										
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3650	-3634	68.2	-3661	-3548	95.4		114.7		99.1
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3694	-3636	68.2	-3712	-3551	95.4		108.3		99.9
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3694	-3636	68.2	-3710	-3555	95.4		106.4		99.9

R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3694	-3629	68.2	-3704	-3551	95.4		105.4			99.4
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3656	-3560	68.2	-3695	-3549	95.5		92.5			98.4
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3640	-3566	68.2	-3648	-3555	95.4		99			95.7
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3646	-3562	68.2	-3652	-3550	95.4		84.1			95.8
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3632	-3586	68.2	-3638	-3557	95.4		116.2			93.9
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											
R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3758	-3571	68.1	-3789	-3551	95.4		106.9			99.8
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3709	-3658	68.2	-3751	-3650	95.4		106.1			100
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3695	-3649	68.2	-3707	-3641	95.4		100.7			100
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3694	-3636	68.2	-3709	-3629	95.4		106			99.8
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3655	-3629	68.2	-3691	-3547	95.4		105.7			98.8
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3730	-3654	68.2	-3756	-3646	95.4		111.3			100
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3696	-3639	68.2	-3753	-3562	95.4		110.2			99.9
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3696	-3633	68.2	-3714	-3549	95.4		108.1			99.7
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3790	95.4		99.7			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3795	-3572	68.2	-3942	-3555	95.5		108.7			99.7
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			100
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.4			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3791	-3715	68.2	-3906	-3707	95.4		99.4			100
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3732	-3636	68.2	-3760	-3558	95.4		125.7			99.9
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3745	-3712	68.2	-3764	-3703	95.4		79.4			100
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3748	-3669	68.2	-3757	-3656	95.4		107.8			100
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3752	-3697	68.2	-3759	-3661	95.4		104			100
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3695	-3650	68.2	-3749	-3637	95.4		102.5			100

R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3696	-3651	68.2	-3749	-3637	95.4		102.4			100
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3695	-3648	68.2	-3715	-3636	95.4		102.2			100
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3695	-3648	68.2	-3711	-3638	95.4		101.5			100
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3695	-3629	68.2	-3707	-3550	95.4		103.8			99.4
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3747	-3666	68.2	-3757	-3658	95.4		104.9			100
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3708	-3657	68.2	-3752	-3648	95.4		106.7			100
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3699	-3651	68.2	-3750	-3638	95.4		104.7			100
Span Duration House South of Ireland							158	203	68.2	115	213	95.4					98
Boundary End Houses							-3571	-3545	68.2	-3618	-3542	95.4					95.4
Boundary Start Ephemeral/Burial/Fish-trap							-3553	-3544	68.2	-3560	-3539	95.4					98.2
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3793	68.3	-3961	-3713	95.4		100			99.9
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3716	68.2	-3965	-3665	95.4		100			99.9
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3932	-3696	68.2	-3946	-3656	95.4		100			99.9
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3551	-3541	68.2	-3557	-3536	95.4		117.9			99.5
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3764	-3543	95.4		100.5			100
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.7			99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3551	-3541	68.2	-3557	-3536	95.4		131.9			99.2
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3551	-3541	68.2	-3556	-3536	95.4		29.9			98.9
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3551	-3541	68.2	-3556	-3536	95.4		38.5			98.9
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3551	-3541	68.2	-3556	-3536	95.4		36.7			98.9

R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3550	-3541	68.2	-3557	-3536	95.4		144.3			99.4
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3632	-3566	68.2	-3656	-3538	95.4		99.5			99.1
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3551	-3540	68.2	-3557	-3536	95.4		131.8			99.5
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3769	-3637	95.4		100.1			99.9
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3551	-3541	68.2	-3556	-3536	95.4		76.3			99
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3550	-3541	68.2	-3557	-3536	95.4		143.4			99.5
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3550	-3540	68.2	-3557	-3536	95.4		138.5			99.5
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3551	-3540	68.2	-3557	-3536	95.4		129.5			99.6
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3551	-3541	68.2	-3557	-3536	95.4		106.2			99.3
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		100			100
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3953	68.2	-4045	-3818	95.4		99.5			99.9
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3942	-3776	68.2	-3951	-3713	95.4		99.9			100
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.9			100
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3651	-3542	68.2	-3662	-3537	95.4		100.8			99.3
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3551	-3541	68.2	-3557	-3536	95.4		139.4			99.4

R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3551	-3541	68.2	-3557	-3536	95.4		144.1			99.2
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3551	-3541	68.2	-3557	-3536	95.4		145.5			99.4
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3550	-3540	68.2	-3557	-3536	95.4		56.9			99.6
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3551	-3541	68.2	-3555	-3537	95.4		0.1			98.6
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3551	-3541	68.2	-3556	-3537	95.4		16.9			98.8
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.8			100
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3550	-3540	68.2	-3557	-3536	95.4		131.6			99.5
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3551	-3540	68.2	-3557	-3536	95.4		112			99.5
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3550	-3540	68.2	-3557	-3536	95.4		60.4			99.6
Span Duration of Occupation							0	10	68.2	0	18	95.4					98
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3546	-3536	68.2	-3552	-3529	95.4		127			98.9
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3546	-3536	68.2	-3552	-3528	95.4		147.8			98.9
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3546	-3536	68.2	-3552	-3528	95.4		135.5			98.9
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3546	-3536	68.2	-3552	-3528	95.4		37.7			98.8
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3546	-3535	68.2	-3552	-3527	95.4		11.1			98.7
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3546	-3536	68.2	-3552	-3528	95.4		60.2			98.8
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3546	-3536	68.2	-3552	-3528	95.4		122.9			98.9
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3546	-3536	68.2	-3552	-3528	95.4		118.2			98.8
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3546	-3536	68.2	-3552	-3528	95.4		146.1			98.9
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3546	-3536	68.2	-3552	-3528	95.4		138			98.9
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3546	-3536	68.2	-3552	-3528	95.4		38			98.8
Phase Lough Gur Site 10																	

R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3546	-3536	68.2	-3552	-3528	95.4		96.3			98.8
Phase Fish-trap																	
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3546	-3532	68.2	-3551	-3524	95.4		127.5			98.2
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3546	-3532	68.2	-3551	-3524	95.4		127.5			98.2
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3538	-3378	68.2	-3543	-3370	95.4		85.2			99.8
Phase Lisduggan North																	
R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3501	-3111	68.2	-3525	-3036	95.4		103			99.9
Span Duration							442	490	68.2	428	553	95.4					98.8
Boundary End Early Neolithic							-3546	-3531	68.2	-3551	-3523	95.4					98

Table C.10 Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 2a (including Domesticates)

C.1.11. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 3

```
Plot("Model 3")
 {
  Sequence("Early Neolithic")
  {
   Boundary("Start Early Neolithic");
   Phase(Early Neolithic)
   {
    Sequence("House South of Ireland")
    {
     Boundary("Start House Occupation");
     Phase("Houses")
     {
      Phase("Ballinglanna North (site 3)")
      {
       After("TPQ Charcoal")
       {
        R_Date("UB-13145", 5010, 25);
        R_Date("UB-13146", 5007, 28);
       };
       R_Date("UBA-10499", 4936, 21);
      };
      Phase("Barnagore (site 3)")
      {
       After("TPQ Charcoal")
       {
        R_Date("Beta-171411", 4880, 70);
        R_Date("Beta-171412", 4950, 70);
       };
      };
      Phase("Caherdrinny (site 3)")
      {
       After("TPQ Charcoal")
       {
        R_Date("UBA-13289", 4877, 26);
        R_Date("UB-13284", 5138, 27);
        R_Date("UB-13286", 4926, 26);
        R_Date("UBA-13292", 5214, 27);
       };
      };
      Phase("Cloghers")
      {
       R_Date("Beta-134227", 4900, 40);
       R_Date("Beta-134226", 4850, 40);
      };
      Phase("Earlsrath")
      {
       After("TPQ Charcoal")
```

```
 {
  R_Date("UBA-14153", 4912, 30);
  R_Date("UBA-14160", 4917, 31);
  R_Date("UBA-14154", 5239, 31);
 };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6769", 4972, 39);
 };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
 };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-10489", 4832, 23);
 };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
 {
  R_Date("GrN-15476", 4860, 70);
```

```
  };
  R_Date("UBA-14791", 4926, 30);
  R_Date("UBA-14788", 4892, 28);
  R_Date("UBA-14789", 4860, 34);
  R_Date("UBA-14790", 4827, 28);
 };
 Phase("Shanagh (site 1)")
 {
  R_Date("UBA-21419", 4930, 45);
  R_Date("UBA-21417", 4870, 47);
  R_Date("UBA-21418", 4850, 47);
 };
 Phase("Tankardstown South")
 {
  After("TPQ Charcoal")
  {
   R_Date("GrN-14713", 5105, 45);
   R_Date("GrN-15387", 4880, 110);
   R_Date("GrN-15386", 5005, 25);
   R_Date("GrN-16558", 5070, 20);
   R_Date("GrN-16557", 4995, 20);
  };
  R_Date("OxA-1476", 4890, 80);
  R_Date("UBA-14739", 5013, 31);
  R_Date("UBA-14780", 4952, 38);
  R_Date("UBA-14737", 4958, 30);
  R_Date("UBA-14734", 4895, 33);
  R_Date("UBA-14735", 4897, 32);
  R_Date("UBA-14738", 4890, 33);
  R_Date("UBA-14736", 4891, 31);
  R_Date("OxA-1477", 4840, 45);
  R_Date("UBA-14742", 4947, 30);
  R_Date("UBA-14743", 4923, 33);
  R_Date("UBA-14740", 4899, 37);
 };
 Span("Duration House South of Ireland");
};
Boundary("End House Occupation");
};
Sequence("Early Neolithic ephemeral sites in the South of Ireland")
{
 Boundary("Start Occupation");
 Phase("Ephemeral Sites")
 {
  Phase("Ballinaspig More (site 4)")
  {
   After("TPQ Charcoal")
   {
    R_Date("Beta-178204", 5050, 50);
   };
```

```
};
Phase("Ballinaspig More (Site 5)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("Beta-178206", 5030, 70);
  R_Date("Beta-178210", 4990, 70);
 };
 R_Date("Beta-178211", 4860, 70);
};
Phase("Bawnfune (site 2) ")
{
 After("TPQ Charcoal")
 {
  R_Date("Poz-24934 ", 4880, 40);
 };
};
Phase("Caherabbey Upper (site 185.1-4)")
{
 After("TPQ Oak Charcoal")
 {
  R_Date("UB-7236", 5119, 38);
 };
 R_Date("UBA-14411", 4822, 30);
 R_Date("UBA-14408", 4856, 30);
 R_Date("UBA-14409", 4850, 29);
 R_Date("UBA-14406", 4849, 28);
 R_Date("UBA-14407", 4801, 28);
};
Phase("Curraghprevin (site 3)")
{
 After("TPQ Charcoal")
 {
  R_Date("Beta-201069", 4720, 80);
 };
};
Phase("Danganbeg (site 10-5)")
{
 R_Date("UBA-24492", 4788, 33);
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
```

```
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
 {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13720", 4822, 32);
 };
};
Phase("Newrath (site 35)")
{
 R_Date("UB-6639", 4827, 39);
 R_Date("UBA-14798", 4809, 26);
 R_Date("UB-6640", 4821, 38);
 R_Date("UBA-14799", 4754, 27);
};
Phase("Scart")
{
 R_Date("Poz-26554", 4960, 40);
 R_Date("UBA-13996", 4861, 28);
 After("TPQ Oak Charcoal")
 {
  R_Date("UBA-13993", 5065, 31);
 };
};
Phase("Suttonrath (site 206.1)")
{
 R_Date("UBA-14809", 4789, 28);
```

```
   R_Date("UBA-14810", 4778, 28);
   R_Date("UB-7208", 4744, 36);
  };
  Span("Duration of Occupation");
 };
 Boundary("End Occupation");
};
Sequence("Neolithic Burials")
{
 Boundary("Start Burials");
 Phase("Burials")
  {
  Phase("Annagh")
   {
   R_Date("GrA-1709", 4840, 60);
   R_Date("GrA-1707", 4810, 60);
   R_Date("GrA-1704", 4780, 60);
   R_Date("GrA-1703", 4670, 70);
   R_Date("GrA-1708", 4640, 60);
  };
  Phase("Carrigdirty Rock")
   {
   R_Date("Beta-102086", 4710, 60);
   R_Date("GrA-27217", 4775, 40);
   R_Date("GrA-27232", 4770, 40);
  };
  Phase("Kilgreany Cave")
   {
   R_Date("Pta-2644", 4820, 60);
   R_Date("GrA-21499", 4790, 50);
   R_Date("BM-135", 4660, 75);
  };
  Phase("Lough Gur Site 10")
   {
   R_Date("GrN-16825", 4740, 60);
  };
 };
 Boundary("End Burials");
};
Sequence("Early Neolithic Field systems/Trackways/Fishtraps South of Ireland")
{
 Boundary("Start Use");
 Phase("Carrigdirty Rock")
  {
  R_Date("Beta-102087", 4820, 50);
  R_Date("GrN-6520", 4820, 50);
 };
 Boundary("End Use");
};
Before("TAQ Linkardstown Burials")
```

```
    {
     Phase("Jerpoint West")
     {
      R_Date("OxA-2680", 4770, 80);
     };
     Phase("Lisduggan North")
     {
      R_Date("OxA-2681",4585, 80);
     };
    };
   };
   Boundary("End Early Neolithic");
  };
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 96.9 Aoverall 94.6				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence																	
Boundary Start 1							-3709	-3671	68.2	-3751	-3664	95.4					98.1
Phase																	
Sequence House South of Ireland																	
Boundary Start House Occupation							-3691	-3667	68.2	-3709	-3663	95.4					98.1
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.1	-3938	-3708	95.4		99.1			100
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.2	-3939	-3706	95.4		99.3			100
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3678	-3658	68.2	-3698	-3651	95.4		104			99.7
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											
R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3757	-3635	68.2	-3904	-3628	95.4		115			99.9
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3792	-3654	68.2	-3942	-3639	95.4		101.9			99.9
Phase Caherdrinny (site 3)																	
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4											
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3700	-3639	95.4		99.7			100
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3983	-3847	68.2	-4033	-3808	95.5		99.4			100
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3651	95.4		99.4			99.9
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4041	-3981	68.2	-4055	-3963	95.4		99.5			99.9
Phase Cloghers																	
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3675	-3646	68.2	-3691	-3638	95.4		118.4			99.8
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3660	-3636	68.2	-3687	-3631	95.4		138.1			99.9
Phase Earlsrath																	

After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4											
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.6			99.9
R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.6			99.9
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4054	-3981	68.2	-4227	-3970	95.3		99.8			99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3655	-3634	68.2	-3681	-3628	95.4		134.5			100
Phase Gortore (site 1)																	
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4											
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3928	-3655	95.4		99.9			100
Phase Granny (site 27)																	
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4											
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3702	-3650	68.2	-3765	-3638	95.4		100.5			99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.3	-3960	-3719	95.4		99.9			99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		100			99.9
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3677	-3653	68.2	-3693	-3644	95.4		115			99.7
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3676	-3651	68.2	-3693	-3641	95.4		113.2			99.8
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3677	-3652	68.2	-3694	-3642	95.4		115			99.7
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3671	-3643	68.2	-3690	-3637	95.4		111.4			99.9
R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3642	-3631	68.2	-3653	-3625	95.4		79.7			99.9
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3648	-3636	68.2	-3658	-3631	95.4		128.3			100
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3665	-3637	68.2	-3687	-3632	95.4		132.7			99.9
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3663	-3637	68.2	-3686	-3633	95.4		126.7			99.9
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3656	-3634	68.2	-3682	-3630	95.4		137.9			100
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3652	-3633	68.2	-3676	-3627	95.4		116.9			100
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3644	-3630	68.2	-3655	-3625	95.4		81.5			99.9
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3645	-3631	68.2	-3653	-3627	95.4		94.5			99.9
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3639	-3630	68.2	-3645	-3624	95.4		62.3			99.6

Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											
R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3708	-3634	68.2	-3795	-3627	95.4		116.2			99.9
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3677	-3654	68.2	-3693	-3645	95.4		114.6			99.7
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3672	-3646	68.2	-3689	-3640	95.4		107			99.8
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3663	-3637	68.2	-3686	-3633	95.4		125.5			99.9
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3648	-3635	68.2	-3659	-3629	95.4		131.2			100
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3677	-3651	68.2	-3692	-3640	95.4		112.1			99.7
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3668	-3639	68.2	-3689	-3633	95.4		135.2			99.8
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3661	-3636	68.2	-3686	-3631	95.4		142.2			99.9
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3791	95.4		99.8			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3780	-3634	68.2	-3943	-3629	95.4		112.6			99.9
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			99.9
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3944	-3805	68.2	-3952	-3799	95.4		99.5			100
R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3792	-3715	68.2	-3906	-3707	95.4		99.4			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3671	-3640	68.2	-3691	-3631	95.4		152.5			99.8
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3677	-3661	68.2	-3707	-3653	95.4		3.4			99.6
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3677	-3656	68.2	-3695	-3645	95.4		78.1			99.7
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3678	-3658	68.2	-3697	-3650	95.4		51.3			99.7
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3673	-3646	68.2	-3690	-3639	95.4		110.9			99.8
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3675	-3647	68.2	-3690	-3639	95.4		110.1			99.8
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3671	-3645	68.2	-3690	-3638	95.4		111.1			99.8
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3671	-3646	68.2	-3689	-3639	95.4		109.2			99.8
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3658	-3634	68.2	-3684	-3629	95.4		138.1			99.9
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3678	-3657	68.2	-3696	-3648	95.4		81.4			99.7
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3677	-3653	68.2	-3694	-3643	95.4		115.8			99.7

R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3675	-3646	68.2	-3691	-3638	95.4		115.3			99.8
Span Duration House South of Ireland							33	58	68.2	27	78	95.4					98
Boundary End House Occupation							-3637	-3627	68.2	-3641	-3620	95.4					99.6
Sequence Early Neolithic ephemeral sites in the South of Ireland																	
Boundary Start Occupation							-3651	-3640	68.2	-3660	-3636	95.4					90.3
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3792	68.2	-3960	-3713	95.4		99.9			99.9
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3942	-3716	68.2	-3965	-3665	95.4		100			99.9
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3932	-3696	68.2	-3945	-3656	95.4		100.3			99.9
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3645	-3633	68.2	-3652	-3627	95.4		152			96.5
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3695	-3642	68.2	-3762	-3633	95.4		104.5			99.9
Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.5			99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3644	-3633	68.2	-3649	-3629	95.4		145			98
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3646	-3636	68.2	-3653	-3632	95.4		135			95.2
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3646	-3635	68.2	-3652	-3631	95.4		140.7			95.3
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3646	-3635	68.2	-3652	-3632	95.4		138.8			95.5
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3642	-3632	68.2	-3648	-3627	95.4		107.7			98.8
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3659	-3626	68.2	-3761	-3619	95.4		47.1			98.4
Phase Danganbeg (site 10-5)																	

R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3641	-3631	68.2	-3647	-3626	95.4		97.7			98.2
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3705	-3647	68.2	-3766	-3638	95.4		101.2			99.9
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3645	-3635	68.2	-3651	-3630	95.4		155.3			96.5
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3642	-3632	68.2	-3649	-3627	95.4		108.7			98.5
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3642	-3631	68.2	-3649	-3626	95.4		104.5			98.2
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3641	-3630	68.2	-3647	-3626	95.4		96.9			98
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3645	-3634	68.2	-3651	-3629	95.4		166.8			96.8
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		99.9			100
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3954	68.2	-4045	-3818	95.4		99.2			99.9
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3941	-3776	68.2	-3951	-3713	95.4		99.9			99.9
Phase Monadreela (site 7)																	
After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.9			99.9
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3650	-3633	68.2	-3694	-3627	95.4		119.2			99.4
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3644	-3633	68.2	-3651	-3628	95.4		157.8			97.5
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3643	-3632	68.2	-3648	-3628	95.4		118.3			99
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3644	-3633	68.2	-3650	-3628	95.4		147.8			97.9
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3637	-3630	68.2	-3642	-3624	95.4		73.1			94.8
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3649	-3638	68.2	-3655	-3633	95.4		6.3			93.1

R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3647	-3636	68.2	-3652	-3632	95.4		123.5			94.5
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3801	68.2	-3956	-3791	95.4		99.7			99.9
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3641	-3630	68.2	-3646	-3626	95.4		95.3			98.2
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3639	-3630	68.2	-3645	-3625	95.4		87.7			97.2
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3638	-3630	68.2	-3644	-3624	95.4		69.6			95.3
Span Duration of Occupation							7	21	68.2	0	29	95.4					80
Boundary End Occupation							-3636	-3625	68.2	-3640	-3621	95.4					88.2
Sequence Neolithic Burials																	
Boundary Start Burials							-3647	-3619	68.2	-3656	-3571	95.4					99.8
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3641	-3584	68.2	-3646	-3552	95.4		87.7			99.7
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3640	-3590	68.2	-3645	-3552	95.4		111.4			99.7
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3639	-3592	68.2	-3643	-3556	95.4		120.8			99.7
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3636	-3600	68.2	-3641	-3558	95.4		69.3			99.7
R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3636	-3602	68.2	-3640	-3560	95.4		34.3			99.7
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3636	-3597	68.2	-3641	-3558	95.4		95.2			99.7
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3639	-3591	68.2	-3641	-3555	95.4		106.6			99.7
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3638	-3592	68.2	-3641	-3555	95.4		110			99.7
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3640	-3587	68.2	-3646	-3551	95.4		105.8			99.7
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3639	-3591	68.2	-3644	-3555	95.4		108.9			99.7
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3636	-3599	68.2	-3641	-3557	95.4		68.5			99.7
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3638	-3595	68.2	-3641	-3556	95.4		116.6			99.7
Boundary End Burials							-3634	-3586	68.2	-3636	-3529	95.4					99.6

Sequence Early Neolithic Field systems/Trackways/Fishtraps South of Ireland																	
Boundary Start Use							-3676	-3634	68.2	-3706	-3566	95.4					99.9
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3658	-3626	68.2	-3676	-3541	95.4		118.6			99.9
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3658	-3626	68.2	-3675	-3541	95.4		118.6			99.9
Boundary End Use							-3651	-3606	68.2	-3661	-3525	95.4					99.8
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3642	-3384	68.2	-3666	-3370	95.4		102.3			99.9
Phase Lisduggan North																	
R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3501	-3111	68.1	-3627	-3030	95.4		99.8			99.9
Boundary End Early Neolithic							-3629	-3568	68.2	-3632	-3489	95.4					98.8

Table C.11 Bayesian mode for the start of the Early Neolithic in the southern region of Ireland – Model 3

C.1.12. Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 3a (including Domesticates)

```
Plot("Model 3a")
 {
  Sequence("Early Neolithic")
  {
   Boundary("Start Early Neolithic");
   Phase(Early Neolithic)
   {
    Sequence("Early Neolithic Domesticates")
    {
     Boundary("Start Domesticates");
     Phase("Domesticates")
     {
      Phase("Ferriter's Cove")
      {
       R_Date("OxA-3869", 5510, 70);
      };
      Phase("Kilgreany Cave")
      {
       R_Date("OxA-4269", 5190, 80);
      };
      Phase("Carrigdirty Rock 5")
      {
       R_Date("GrA-27216", 4775, 40);
      };
      Phase("Annagh Cave")
      {
       R_Date("GrA-1706", 4750, 60);
      };
     };
     Boundary("End Domesticates");
    };
    Sequence("House South of Ireland")
    {
     Boundary("Start House Occupation");
     Phase("Houses")
     {
      Phase("Ballinglanna North (site 3)")
      {
       After("TPQ Charcoal")
       {
        R_Date("UB-13145", 5010, 25);
        R_Date("UB-13146", 5007, 28);
       };
       R_Date("UBA-10499", 4936, 21);
      };
      Phase("Barnagore (site 3)")
      {
```

```
 After("TPQ Charcoal")
  {
  R_Date("Beta-171411", 4880, 70);
  R_Date("Beta-171412", 4950, 70);
  };
};
Phase("Caherdrinny (site 3)")
{
 After("TPQ Charcoal")
  {
  R_Date("UBA-13289", 4877, 26);
  R_Date("UB-13284", 5138, 27);
  R_Date("UB-13286", 4926, 26);
  R_Date("UBA-13292", 5214, 27);
  };
};
Phase("Cloghers")
{
 R_Date("Beta-134227", 4900, 40);
 R_Date("Beta-134226", 4850, 40);
};
Phase("Earlsrath")
{
 After("TPQ Charcoal")
  {
  R_Date("UBA-14153", 4912, 30);
  R_Date("UBA-14160", 4917, 31);
  R_Date("UBA-14154", 5239, 31);
  };
 R_Date("UBA-14158", 4835, 41);
};
Phase("Gortore (site 1)")
{
 After("TPQ Charcoal")
  {
  R_Date("UB-6769", 4972, 39);
  };
};
Phase("Granny (site 27)")
{
 After("TPQ Charcoal")
  {
  R_Date("UB-6635", 4902, 38);
  R_Date("UB-6315", 5054, 38);
  R_Date("UB-6633", 5046, 39);
  };
 R_Date("UBA-14683", 4926, 33);
 R_Date("UBA-14684", 4911, 32);
 R_Date("UBA-14686", 4918, 32);
 R_Date("UBA-14685", 4884, 32);
```

```
 R_Date("UB-6634", 4776, 39);
};
Phase("Kilkeasy")
{
 After("TPQ Charcoal")
  {
  R_Date("UBA-10489", 4832, 23);
  };
 R_Date("Poz-26458", 4860, 40);
 R_Date("Poz-25475", 4860, 35);
 R_Date("Poz-26459", 4840, 40);
 R_Date("Poz-26461", 4820, 40);
 R_Date("Poz-26460", 4780, 40);
};
Phase("Marlfield")
{
 R_Date("UBA-14792", 4800, 31);
 R_Date("UBA-14793", 4747, 32);
};
Phase("Pepperhill")
{
 After("TPQ Charcoal")
  {
  R_Date("GrN-15476", 4860, 70);
  };
 R_Date("UBA-14791", 4926, 30);
 R_Date("UBA-14788", 4892, 28);
 R_Date("UBA-14789", 4860, 34);
 R_Date("UBA-14790", 4827, 28);
};
Phase("Shanagh (site 1)")
{
 R_Date("UBA-21419", 4930, 45);
 R_Date("UBA-21417", 4870, 47);
 R_Date("UBA-21418", 4850, 47);
};
Phase("Tankardstown South")
{
 After("TPQ Charcoal")
  {
  R_Date("GrN-14713", 5105, 45);
  R_Date("GrN-15387", 4880, 110);
  R_Date("GrN-15386", 5005, 25);
  R_Date("GrN-16558", 5070, 20);
  R_Date("GrN-16557", 4995, 20);
  };
 R_Date("OxA-1476", 4890, 80);
 R_Date("UBA-14739", 5013, 31);
 R_Date("UBA-14780", 4952, 38);
 R_Date("UBA-14737", 4958, 30);
```

```
   R_Date("UBA-14734", 4895, 33);
   R_Date("UBA-14735", 4897, 32);
   R_Date("UBA-14738", 4890, 33);
   R_Date("UBA-14736", 4891, 31);
   R_Date("OxA-1477", 4840, 45);
   R_Date("UBA-14742", 4947, 30);
   R_Date("UBA-14743", 4923, 33);
   R_Date("UBA-14740", 4899, 37);
  };
  Span("Duration House South of Ireland");
 };
 Boundary("End House Occupation");
};
Sequence("Early Neolithic ephemeral sites in the South of Ireland")
{
 Boundary("Start Occupation");
 Phase("Ephemeral Sites")
 {
  Phase("Ballinaspig More (site 4)")
  {
   After("TPQ Charcoal")
   {
    R_Date("Beta-178204", 5050, 50);
   };
  };
  Phase("Ballinaspig More (Site 5)")
  {
   After("TPQ Oak Charcoal")
   {
    R_Date("Beta-178206", 5030, 70);
    R_Date("Beta-178210", 4990, 70);
   };
   R_Date("Beta-178211", 4860, 70);
  };
  Phase("Bawnfune (site 2) ")
  {
   After("TPQ Charcoal")
   {
    R_Date("Poz-24934 ", 4880, 40);
   };
  };
  Phase("Caherabbey Upper (site 185.1-4)")
  {
   After("TPQ Oak Charcoal")
   {
    R_Date("UB-7236", 5119, 38);
   };
   R_Date("UBA-14411", 4822, 30);
   R_Date("UBA-14408", 4856, 30);
   R_Date("UBA-14409", 4850, 29);
```

```
 R_Date("UBA-14406", 4849, 28);
 R_Date("UBA-14407", 4801, 28);
};
Phase("Curraghprevin (site 3)")
{
 After("TPQ Charcoal")
 {
  R_Date("Beta-201069", 4720, 80);
 };
};
Phase("Danganbeg (site 10-5)")
{
 R_Date("UBA-24492", 4788, 33);
};
Phase("Kilsheelan")
{
 After("TPQ Charcoal")
 {
  R_Date("UB-6960", 4900, 41);
 };
 R_Date("UBA-14670", 4839, 30);
 R_Date("UBA-14671", 4799, 33);
 R_Date("UBA-14673", 4793, 36);
 R_Date("UBA-14672", 4786, 34);
 R_Date("UB-6961", 4841, 39);
};
Phase("Manor East (site 1)")
{
 After("TPQ Charcoal")
 {
  R_Date("Suerc-37321", 4955, 35);
  R_Date("Suerc-37323", 5165, 35);
 };
};
Phase("Manor West")
{
 After("TPQ Charcoal")
 {
  R_Date("QUB-7654", 5036, 40);
 };
};
Phase("Monadreela (site 7)")
{
 After("TPQ Charcoal")
 {
  R_Date("UBA-13711", 5050, 32);
 };
};
Phase("Monadreela (site 9)")
{
```

```
   After("TPQ Charcoal")
   {
    R_Date("UBA-13720", 4822, 32);
   };
  };
  Phase("Newrath (site 35)")
  {
   R_Date("UB-6639", 4827, 39);
   R_Date("UBA-14798", 4809, 26);
   R_Date("UB-6640", 4821, 38);
   R_Date("UBA-14799", 4754, 27);
  };
  Phase("Scart")
  {
   R_Date("Poz-26554", 4960, 40);
   R_Date("UBA-13996", 4861, 28);
   After("TPQ Oak Charcoal")
   {
    R_Date("UBA-13993", 5065, 31);
   };
  };
  Phase("Suttonrath (site 206.1)")
  {
   R_Date("UBA-14809", 4789, 28);
   R_Date("UBA-14810", 4778, 28);
   R_Date("UB-7208", 4744, 36);
  };
  Span("Duration of Occupation");
 };
 Boundary("End Occupation");
};
Sequence("Neolithic Burials")
{
 Boundary("Start Burials");
 Phase("Burials")
 {
  Phase("Annagh")
  {
   R_Date("GrA-1709", 4840, 60);
   R_Date("GrA-1707", 4810, 60);
   R_Date("GrA-1704", 4780, 60);
   R_Date("GrA-1703", 4670, 70);
   R_Date("GrA-1708", 4640, 60);
  };
  Phase("Carrigdirty Rock")
  {
   R_Date("Beta-102086", 4710, 60);
   R_Date("GrA-27217", 4775, 40);
   R_Date("GrA-27232", 4770, 40);
  };
```

```
   Phase("Kilgreany Cave")
   {
    R_Date("Pta-2644", 4820, 60);
    R_Date("GrA-21499", 4790, 50);
    R_Date("BM-135", 4660, 75);
   };
   Phase("Lough Gur Site 10")
   {
    R_Date("GrN-16825", 4740, 60);
   };
  };
  Boundary("End Burials");
 };
 Sequence("Early Neolithic Field systems/Trackways/Fishtraps South of Ireland")
 {
  Boundary("Start Use");
  Phase("Carrigdirty Rock")
  {
   R_Date("Beta-102087", 4820, 50);
   R_Date("GrN-6520", 4820, 50);
  };
  Boundary("End Use");
 };
 Before("TAQ Linkardstown Burials")
 {
  Phase("Jerpoint West")
  {
   R_Date("OxA-2680", 4770, 80);
  };
  Phase("Lisduggan North")
  {
   R_Date("OxA-2681",4585, 80);
  };
 };
 Span();
};
Boundary("End Early Neolithic");
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 75.9 Aoverall 71.1				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Early Neolithic																	
Boundary Start Early Neolithic							-4428	-4088	68.2	-4712	-4059	95.4					99.6
Phase Early Neolithic																	
Sequence Early Neolithic Domesticates																	
Boundary Start Domesticates							-4376	-4061	68.2	-4516	-4010	95.4					99.9
Phase Domesticates																	
Phase Ferriter's Cove																	
R_Date OxA-3869	-4449	-4272	68.2	-4502	-4183	95.4	-4354	-4047	68.2	-4408	-3995	95.4		36.7			99.9
Phase Kilgreany Cave																	
R_Date OxA-4269	-4224	-3816	68.1	-4234	-3798	95.4	-4073	-3812	68.2	-4227	-3796	95.4		49.3			99.9
Phase Carrigdirty Rock 5																	
R_Date GrA-27216	-3636	-3526	68.2	-3646	-3382	95.4	-3639	-3550	68.2	-3646	-3518	95.4		105.7			100
Phase Annagh Cave																	
R_Date GrA-1706	-3635	-3385	68.2	-3645	-3373	95.4	-3639	-3552	68.2	-3658	-3405	95.4		109.6			100
Boundary End Domesticates							-3586	-3453	68.2	-3627	-3294	95.4					100
Sequence House South of Ireland																	
Boundary Start House Occupation							-3710	-3679	68.2	-3721	-3669	95.4					96.9
Phase Houses																	
Phase Ballinglanna North (site 3)																	
After TPQ Charcoal	-3737.5	...	68.2	-3712	...	95.4											
R_Date UB-13145	-3908	-3715	68.1	-3938	-3708	95.4	-3908	-3715	68.2	-3938	-3708	95.4		99.2			99.9
R_Date UB-13146	-3906	-3714	68.1	-3939	-3706	95.4	-3906	-3714	68.3	-3939	-3706	95.4		99.3			100
R_Date UBA-10499	-3712	-3661	68.2	-3766	-3656	95.4	-3686	-3658	68.2	-3706	-3654	95.4		110.2			99.2
Phase Barnagore (site 3)																	
After TPQ Charcoal	-3643	...	68.2	-3533	...	95.4											

R_Date Beta-171411	-3764	-3539	68.2	-3923	-3389	95.4	-3757	-3635	68.2	-3905	-3627	95.4		114.7		99.9
R_Date Beta-171412	-3796	-3651	68.2	-3943	-3638	95.4	-3793	-3653	68.2	-3942	-3638	95.4		101.8		100
Phase Caherdrinny (site 3)																
After TPQ Charcoal	-3651.5	...	68.2	-3639.5	...	95.4										
R_Date UBA-13289	-3694	-3641	68.2	-3701	-3638	95.4	-3694	-3642	68.2	-3700	-3639	95.4		99.6		99.9
R_Date UB-13284	-3982	-3847	68.2	-4034	-3808	95.4	-3982	-3847	68.2	-4033	-3808	95.4		99.2		100
R_Date UB-13286	-3709	-3658	68.2	-3766	-3650	95.4	-3709	-3658	68.2	-3765	-3650	95.4		99.4		99.9
R_Date UBA-13292	-4041	-3981	68.2	-4054	-3963	95.4	-4040	-3981	68.2	-4055	-3963	95.4		99.6		99.9
Phase Cloghers																
R_Date Beta-134227	-3705	-3648	68.2	-3768	-3638	95.4	-3684	-3647	68.2	-3700	-3639	95.4		119.5		99.5
R_Date Beta-134226	-3695	-3539	68.2	-3709	-3527	95.4	-3664	-3634	68.2	-3695	-3631	95.4		129.6		99.9
Phase Earlsrath																
After TPQ Charcoal	-3661	...	68.2	-3647	...	95.4										
R_Date UBA-14153	-3702	-3656	68.2	-3764	-3643	95.4	-3702	-3656	68.2	-3763	-3643	95.4		99.7		100
R_Date UBA-14160	-3706	-3656	68.2	-3766	-3645	95.4	-3706	-3656	68.2	-3765	-3645	95.4		99.6		99.9
R_Date UBA-14154	-4143	-3981	68.2	-4227	-3971	95.4	-4143	-3981	68.2	-4227	-3970	95.3		99.7		99.9
R_Date UBA-14158	-3660	-3535	68.2	-3702	-3525	95.4	-3659	-3632	68.2	-3691	-3629	95.4		126.6		99.9
Phase Gortore (site 1)																
After TPQ Charcoal	-3723.5	...	68.2	-3670	...	95.4										
R_Date UB-6769	-3791	-3701	68.2	-3928	-3655	95.4	-3791	-3701	68.2	-3928	-3655	95.4		99.9		99.9
Phase Granny (site 27)																
After TPQ Charcoal	-3666.5	...	68.2	-3644	...	95.4										
R_Date UB-6635	-3703	-3650	68.2	-3766	-3638	95.4	-3702	-3650	68.2	-3765	-3638	95.4		100.5		99.9
R_Date UB-6315	-3942	-3797	68.2	-3960	-3719	95.4	-3942	-3797	68.2	-3960	-3719	95.4		99.9		99.9
R_Date UB-6633	-3942	-3790	68.2	-3957	-3715	95.5	-3942	-3790	68.2	-3957	-3715	95.4		99.9		100
R_Date UBA-14683	-3713	-3654	68.2	-3772	-3648	95.4	-3685	-3655	68.2	-3706	-3646	95.4		119.4		99.4
R_Date UBA-14684	-3703	-3655	68.2	-3766	-3642	95.4	-3686	-3652	68.2	-3702	-3644	95.4		115.6		99.5
R_Date UBA-14686	-3707	-3655	68.2	-3766	-3645	95.4	-3685	-3653	68.2	-3703	-3646	95.4		118.4		99.5
R_Date UBA-14685	-3695	-3644	68.2	-3713	-3635	95.4	-3679	-3643	68.2	-3697	-3638	95.4		108.7		99.7

R_Date UB-6634	-3636	-3526	68.2	-3646	-3382	95.4	-3642	-3629	68.2	-3654	-3622	95.4		85.3			99.8
Phase Kilkeasy																	
After TPQ Charcoal	-3563.5	...	68.2	-3539	...	95.4											
R_Date UBA-10489	-3651	-3541	68.2	-3657	-3535	95.4	-3647	-3636	68.2	-3657	-3631	95.4		127.6			100
R_Date Poz-26458	-3695	-3636	68.2	-3712	-3529	95.4	-3670	-3636	68.2	-3696	-3633	95.4		125.3			99.8
R_Date Poz-25475	-3695	-3636	68.2	-3708	-3536	95.4	-3667	-3636	68.2	-3693	-3634	95.4		119.2			99.9
R_Date Poz-26459	-3692	-3536	68.2	-3704	-3526	95.4	-3660	-3633	68.2	-3691	-3630	95.4		129.4			99.9
R_Date Poz-26461	-3651	-3534	68.2	-3695	-3521	95.4	-3653	-3632	68.2	-3691	-3626	95.4		112.3			100
R_Date Poz-26460	-3637	-3526	68.2	-3648	-3383	95.4	-3643	-3629	68.2	-3657	-3622	95.4		86			99.9
Phase Marlfield																	
R_Date UBA-14792	-3640	-3533	68.2	-3650	-3522	95.4	-3643	-3631	68.2	-3653	-3626	95.4		95.7			99.9
R_Date UBA-14793	-3632	-3519	68.2	-3636	-3381	95.4	-3638	-3628	68.2	-3644	-3622	95.4		74.8			99.7
Phase Pepperhill																	
After TPQ Charcoal	-3602.5	...	68.2	-3511.5	...	95.4											
R_Date GrN-15476	-3712	-3530	68.2	-3797	-3383	95.4	-3709	-3633	68.2	-3796	-3626	95.4		116			99.9
R_Date UBA-14791	-3711	-3654	68.2	-3767	-3650	95.4	-3685	-3655	68.2	-3705	-3648	95.4		118.8			99.4
R_Date UBA-14788	-3695	-3649	68.2	-3708	-3640	95.4	-3683	-3647	68.2	-3698	-3641	95.4		106			99.6
R_Date UBA-14789	-3694	-3636	68.2	-3708	-3536	95.4	-3667	-3636	68.2	-3693	-3634	95.4		117.9			99.8
R_Date UBA-14790	-3652	-3538	68.2	-3661	-3527	95.4	-3648	-3634	68.2	-3663	-3627	95.4		128.7			100
Phase Shanagh (site 1)																	
R_Date UBA-21419	-3761	-3654	68.2	-3796	-3640	95.4	-3687	-3652	68.2	-3706	-3641	95.4		116.9			99.4
R_Date UBA-21417	-3703	-3636	68.2	-3766	-3532	95.4	-3676	-3638	68.2	-3698	-3633	95.4		130.5			99.7
R_Date UBA-21418	-3696	-3538	68.2	-3758	-3522	95.4	-3668	-3634	68.2	-3695	-3631	95.4		134			99.8
Phase Tankardstown South																	
After TPQ Charcoal	-3616.5	...	68.2	-3414	...	95.4											
R_Date GrN-14713	-3966	-3806	68.2	-3984	-3790	95.4	-3966	-3806	68.2	-3984	-3790	95.4		99.8			99.9
R_Date GrN-15387	-3796	-3524	68.2	-3948	-3378	95.4	-3781	-3634	68.2	-3943	-3628	95.4		112.5			99.9
R_Date GrN-15386	-3895	-3713	68.2	-3935	-3707	95.4	-3896	-3713	68.2	-3935	-3707	95.4		99.2			99.9
R_Date GrN-16558	-3944	-3804	68.2	-3951	-3799	95.4	-3943	-3805	68.2	-3952	-3799	95.4		99.5			100

R_Date GrN-16557	-3792	-3715	68.2	-3906	-3707	95.4	-3791	-3715	68.2	-3906	-3707	95.4		99.5			99.9
R_Date OxA-1476	-3779	-3539	68.2	-3942	-3386	95.4	-3680	-3640	68.2	-3702	-3631	95.4		152			99.6
R_Date UBA-14739	-3914	-3714	68.3	-3943	-3707	95.5	-3710	-3660	68.2	-3717	-3657	95.4		10.5			98.4
R_Date UBA-14780	-3772	-3671	68.2	-3891	-3651	95.4	-3686	-3655	68.2	-3709	-3648	95.4		84.5			99.2
R_Date UBA-14737	-3772	-3701	68.2	-3792	-3659	95.4	-3687	-3657	68.2	-3711	-3653	95.4		59.1			99
R_Date UBA-14734	-3696	-3650	68.2	-3761	-3637	95.4	-3684	-3647	68.2	-3699	-3640	95.4		110.9			99.5
R_Date UBA-14735	-3696	-3651	68.2	-3761	-3637	95.4	-3683	-3648	68.2	-3700	-3641	95.4		110.4			99.5
R_Date UBA-14738	-3696	-3647	68.2	-3761	-3636	95.4	-3679	-3646	68.2	-3698	-3639	95.4		110			99.6
R_Date UBA-14736	-3695	-3648	68.2	-3749	-3637	95.4	-3680	-3646	68.2	-3697	-3640	95.4		108.2			99.6
R_Date OxA-1477	-3692	-3536	68.2	-3708	-3522	95.4	-3664	-3632	68.2	-3692	-3630	95.4		129.5			99.9
R_Date UBA-14742	-3765	-3666	68.2	-3782	-3656	95.4	-3687	-3656	68.2	-3710	-3651	95.4		88.3			99.3
R_Date UBA-14743	-3712	-3653	68.2	-3771	-3647	95.4	-3685	-3654	68.2	-3705	-3646	95.4		119.7			99.4
R_Date UBA-14740	-3701	-3650	68.2	-3766	-3637	95.4	-3684	-3647	68.2	-3700	-3640	95.4		116.2			99.6
Span Duration House South of Ireland							46	79	68.2	33	92	95.4					97.1
Boundary End House Occupation							-3635	-3624	68.2	-3640	-3618	95.4					99.4
Sequence Early Neolithic ephemeral sites in the South of Ireland																	
Boundary Start Occupation							-3680	-3654	68.2	-3705	-3648	95.4					99.9
Phase Ephemeral Sites																	
Phase Ballinaspig More (site 4)																	
After TPQ Charcoal	-3815.5	...	68.2	-3726.5	...	95.4											
R_Date Beta-178204	-3943	-3793	68.1	-3961	-3713	95.4	-3943	-3792	68.2	-3961	-3713	95.4		100			99.9
Phase Ballinaspig More (Site 5)																	
After TPQ Oak Charcoal	-3721.5	...	68.2	-3661	...	95.4											
R_Date Beta-178206	-3943	-3716	68.1	-3965	-3665	95.4	-3943	-3716	68.2	-3965	-3665	95.4		100			99.9
R_Date Beta-178210	-3932	-3696	68.2	-3946	-3656	95.4	-3933	-3696	68.2	-3946	-3656	95.4		100			99.9
R_Date Beta-178211	-3712	-3530	68.2	-3797	-3383	95.4	-3666	-3541	68.2	-3680	-3532	95.4		117.2			100
Phase Bawnfune (site 2)																	
After TPQ Charcoal	-3654.5	...	68.2	-3573	...	95.4											
R_Date Poz-24934	-3696	-3641	68.2	-3765	-3538	95.4	-3696	-3642	68.2	-3765	-3541	95.4		100.3			99.9

Phase Caherabbey Upper (site 185.1-4)																	
After TPQ Oak Charcoal	-3847.5	...	68.2	-3809	...	95.4											
R_Date UB-7236	-3971	-3812	68.2	-3987	-3798	95.4	-3972	-3812	68.2	-3987	-3798	95.4		99.6			99.9
R_Date UBA-14411	-3651	-3536	68.2	-3658	-3526	95.4	-3651	-3539	68.2	-3657	-3532	95.4		100.9			100
R_Date UBA-14408	-3692	-3636	68.2	-3705	-3537	95.4	-3660	-3636	68.2	-3687	-3537	95.4		116.2			100
R_Date UBA-14409	-3662	-3543	68.2	-3702	-3536	95.4	-3657	-3635	68.2	-3675	-3536	95.4		112.5			100
R_Date UBA-14406	-3661	-3543	68.2	-3701	-3536	95.4	-3656	-3635	68.2	-3672	-3537	95.4		111.2			100
R_Date UBA-14407	-3640	-3535	68.2	-3647	-3524	95.4	-3641	-3539	68.2	-3648	-3531	95.4		98.2			99.9
Phase Curraghprevin (site 3)																	
After TPQ Charcoal	-3441.5	...	68.2	-3368	...	95.4											
R_Date Beta-201069	-3632	-3377	68.1	-3651	-3356	95.4	-3633	-3561	68.2	-3657	-3519	95.4		100.3			99.9
Phase Danganbeg (site 10-5)																	
R_Date UBA-24492	-3638	-3531	68.2	-3646	-3519	95.4	-3639	-3539	68.2	-3645	-3530	95.4		102.6			100
Phase Kilsheelan																	
After TPQ Charcoal	-3666	...	68.2	-3642	...	95.4											
R_Date UB-6960	-3706	-3646	68.2	-3771	-3637	95.4	-3706	-3646	68.2	-3770	-3637	95.4		100.1			99.9
R_Date UBA-14670	-3656	-3539	68.2	-3696	-3532	95.4	-3656	-3541	68.2	-3667	-3533	95.4		107.6			100
R_Date UBA-14671	-3641	-3532	68.2	-3651	-3521	95.4	-3641	-3539	68.2	-3649	-3530	95.4		100.7			100
R_Date UBA-14673	-3640	-3530	68.2	-3651	-3518	95.4	-3641	-3538	68.2	-3647	-3530	95.4		103.3			100
R_Date UBA-14672	-3638	-3530	68.2	-3647	-3389	95.4	-3639	-3540	68.2	-3644	-3531	95.4		103.6			100
R_Date UB-6961	-3692	-3537	68.3	-3704	-3526	95.4	-3660	-3539	68.2	-3676	-3531	95.4		111.8			100
Phase Manor East (site 1)																	
After TPQ Charcoal	-3707.5	...	68.2	-3663.5	...	95.4											
R_Date Suerc-37321	-3775	-3695	68.2	-3798	-3652	95.4	-3775	-3695	68.2	-3798	-3652	95.4		99.9			100
R_Date Suerc-37323	-4036	-3954	68.2	-4045	-3817	95.4	-4036	-3953	68.2	-4045	-3817	95.4		99.3			99.9
Phase Manor West																	
After TPQ Charcoal	-3805.5	...	68.2	-3725.5	...	95.4											
R_Date QUB-7654	-3941	-3776	68.2	-3951	-3713	95.4	-3941	-3776	68.2	-3951	-3713	95.4		99.9			100
Phase Monadreela (site 7)																	

After TPQ Charcoal	-3833	...	68.2	-3775	...	95.4											
R_Date UBA-13711	-3941	-3794	68.2	-3956	-3771	95.4	-3941	-3794	68.2	-3956	-3771	95.4		99.9			100
Phase Monadreela (site 9)																	
After TPQ Charcoal	-3552.5	...	68.2	-3533.5	...	95.4											
R_Date UBA-13720	-3651	-3536	68.3	-3661	-3524	95.4	-3651	-3539	68.2	-3662	-3529	95.4		99.4			100
Phase Newrath (site 35)																	
R_Date UB-6639	-3654	-3535	68.2	-3696	-3523	95.4	-3654	-3539	68.2	-3665	-3529	95.4		106.6			100
R_Date UBA-14798	-3643	-3536	68.2	-3651	-3526	95.4	-3644	-3539	68.2	-3651	-3531	95.4		97.3			100
R_Date UB-6640	-3651	-3535	68.2	-3695	-3521	95.4	-3651	-3539	68.2	-3661	-3530	95.4		104.4			99.9
R_Date UBA-14799	-3633	-3521	68.2	-3637	-3384	95.4	-3632	-3561	68.2	-3636	-3529	95.4		109.4			100
Phase Scart																	
R_Date Poz-26554	-3783	-3695	68.2	-3909	-3651	95.4	-3670	-3649	68.2	-3688	-3640	95.4		51.2			99.9
R_Date UBA-13996	-3692	-3637	68.2	-3703	-3542	95.4	-3658	-3638	68.2	-3687	-3540	95.4		117.9			100
After TPQ Oak Charcoal	-3838.5	...	68.2	-3794	...	95.4											
R_Date UBA-13993	-3943	-3801	68.2	-3956	-3791	95.4	-3943	-3802	68.2	-3956	-3791	95.4		99.8			100
Phase Suttonrath (site 206.1)																	
R_Date UBA-14809	-3638	-3533	68.2	-3643	-3522	95.4	-3638	-3540	68.2	-3644	-3530	95.4		100			100
R_Date UBA-14810	-3636	-3529	68.2	-3641	-3520	95.4	-3636	-3542	68.2	-3640	-3530	95.4		102.2			100
R_Date UB-7208	-3633	-3386	68.2	-3637	-3379	95.4	-3631	-3567	68.2	-3636	-3530	95.4		114.9			100
Span Duration of Occupation							107	140	68.2	87	167	95.4					99.9
Boundary End Occupation							-3546	-3520	68.2	-3569	-3502	95.4					99.9
Sequence Neolithic Burials																	
Boundary Start Burials							-3646	-3576	68.2	-3663	-3532	95.4					99.8
Phase Burials																	
Phase Annagh																	
R_Date GrA-1709	-3696	-3532	68.2	-3766	-3384	95.4	-3597	-3533	68.2	-3644	-3522	95.4		96.6			100
R_Date GrA-1707	-3655	-3522	68.2	-3706	-3379	95.4	-3598	-3533	68.2	-3639	-3521	95.4		119.4			100
R_Date GrA-1704	-3642	-3519	68.2	-3660	-3375	95.4	-3602	-3530	68.2	-3637	-3518	95.4		124			100
R_Date GrA-1703	-3620	-3367	68.2	-3639	-3138	95.5	-3623	-3522	68.2	-3635	-3498	95.4		71.2			100

R_Date GrA-1708	-3516	-3359	68.2	-3633	-3123	95.5	-3623	-3516	68.2	-3633	-3492	95.4		44.1			99.9
Phase Carrigdirty Rock																	
R_Date Beta-102086	-3629	-3376	68.2	-3635	-3370	95.4	-3617	-3524	68.2	-3634	-3505	95.4		92.3			99.9
R_Date GrA-27217	-3636	-3526	68.2	-3646	-3382	95.4	-3601	-3529	68.2	-3635	-3521	95.4		113.7			100
R_Date GrA-27232	-3636	-3524	68.2	-3644	-3381	95.4	-3602	-3528	68.2	-3634	-3521	95.4		115.2			100
Phase Kilgreany Cave																	
R_Date Pta-2644	-3661	-3523	68.2	-3711	-3379	95.4	-3598	-3533	68.2	-3640	-3521	95.4		114.7			100
R_Date GrA-21499	-3641	-3524	68.2	-3659	-3379	95.4	-3599	-3532	68.2	-3637	-3521	95.4		116.8			100
R_Date BM-135	-3622	-3362	68.2	-3640	-3119	95.4	-3623	-3523	68.2	-3635	-3497	95.4		71.2			99.9
Phase Lough Gur Site 10																	
R_Date GrN-16825	-3633	-3382	68.2	-3641	-3372	95.4	-3611	-3524	68.2	-3636	-3511	95.4		113.5			100
Boundary End Burials							-3582	-3502	68.2	-3628	-3464	95.4					99.9
Sequence Early Neolithic Field systems/Trackways/Fishtraps South of Ireland																	
Boundary Start Use							-3713	-3546	68.2	-4014	-3528	95.4					99.7
Phase Carrigdirty Rock																	
R_Date Beta-102087	-3656	-3527	68.2	-3705	-3385	95.4	-3653	-3535	68.2	-3693	-3522	95.4		108.7			100
R_Date GrN-6520	-3656	-3527	68.2	-3705	-3385	95.4	-3653	-3535	68.2	-3692	-3522	95.4		108.7			99.9
Boundary End Use							-3640	-3485	68.2	-3661	-3357	95.4					99.9
Before TAQ Linkardstown Burials																	
Phase Jerpoint West																	
R_Date OxA-2680	-3642	-3383	68.2	-3695	-3370	95.4	-3642	-3384	68.2	-3694	-3370	95.4		99.9			99.9
Phase Lisduggan North																	
R_Date OxA-2681	-3501	-3109	68.3	-3627	-3029	95.4	-3501	-3109	68.3	-3626	-3030	95.4		99.8			99.9
Span							548	880	68.2	492	1177	95.4					99.9
Boundary End Early Neolithic							-3525	-3329	68.2	-3546	-2969	95.4					99.7

Table C.12 Bayesian model for the start of the Early Neolithic in the southern region of Ireland – Model 3a (including Domesticates)

C.2. Bayesian and *P_Sequence* Models outlined in Chapter 5

C.2.1. OxCal *P_Sequence* model for Lough Cullin (LC) with radiocarbon date SUERC-70843 included

```
Plot(“LC with SUERC-70843 included”)
 {
  P_Sequence("LC",1,0.01,U(-2,2))
  {
   Boundary(“base of profile)
   {
    z=622;
   };
   R_Date("UBA-22427", 9057, 48)
   {
    z=621;
   };
   R_Date("UB-30918", 7358, 37)
   {
    z=591;
   };
   R_Date("UBA-22426", 6154, 47)
   {
    z=546;
   };
   R_Combine(“534cm”)
   {
    z=534;
    R_Date("SUERC-70844", 5788, 26)
     {
    };
    R_Date("SUERC-70843", 5675, 27);
   };
   R_Date("UBA-30917", 5210, 34)
   {
    z=501;
   };
   R_Date("UBA-33722", 5076, 51)
   {
    z=497;
   };
   R_Date("UBA-33721", 5080, 56)
   {
    z=487;
   };
   R_Combine("469cm")
   {
    z=469;
    R_Date("SUERC-70841", 4755, 29);
    R_Date("SUERC-70842", 4795, 26);
   };
   R_Date("UBA-22425", 4710, 39)
   {
    z=460;
   };
   R_Combine("431cm")
   {
    z=431;
```

```
  R_Date("SUERC-70836", 4459, 29);
  R_Date("SUERC-70837", 4520, 27);
 };
 Boundary(top of profile)
 {
  z=428;
 };
 };
};
```

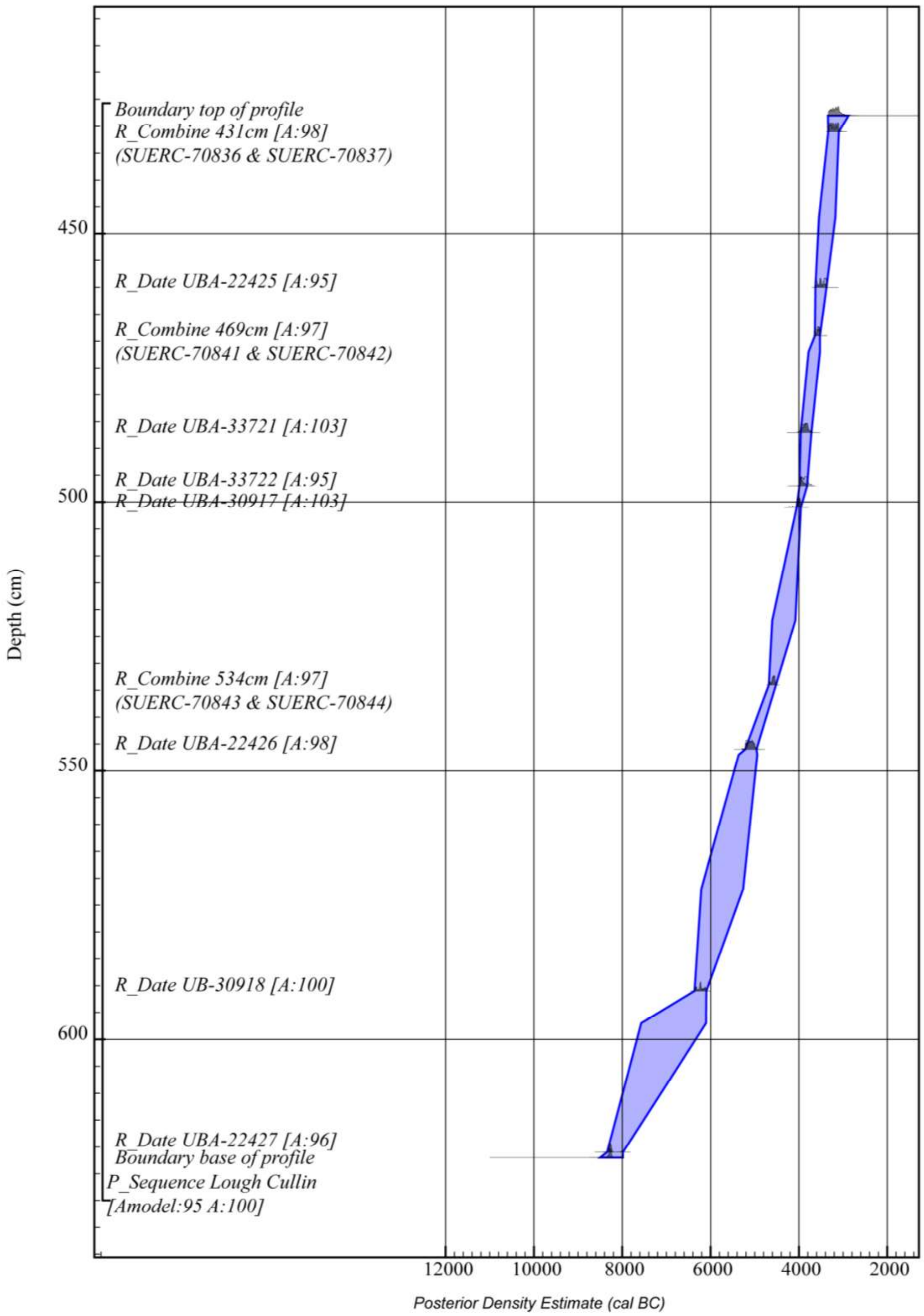

Figure C.1 Bayesian age-model of the chronology of the sediment sequence at Lough Cullin (P_Sequence model (k=0.01-100) (Bronk Ramsey, 2008; Bronk Ramsey and Lee, 2013) with SUERC-70843 included. Blue band showing the estimated date of sediment at the corresponding depth at 95.4% probability

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 94.5 Aoverall 94.7				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence LC	-2	2	68.2	-2	2	95.4	-1.20641	-0.92241	68.2	-1.26641	-0.74641	95.4		100			99.4
Boundary base of profile							-8315	-8238	68.2	-8501	-7985	95.3					97.9
R_Date UBA-22427	-8295	-8248	68.2	-8422	-8208	95.4	-8295	-8245	68.2	-8345	-7986	95.3		95.9			98.7
R_Date UB-30918	-6339	-6106	68.2	-6360	-6091	95.4	-6348	-6110	68.2	-6364	-6096	95.4		99.5			99.9
R_Date UBA-22426	-5207	-5048	68.2	-5221	-4961	95.4	-5195	-5018	68.2	-5217	-4961	95.4		97.9			99.9
R_Combine 534cm	-4606	-4541	68.2	-4680	-4505	95.4	-4610	-4541	68.2	-4682	-4520	95.4		97.2			100
R_Date UBA-30917	-4041	-3976	68.2	-4221	-3958	95.4	-4036	-3969	68.2	-4051	-3957	95.4		102.8			99.9
R_Date UBA-33722	-3953	-3801	68.2	-3975	-3715	95.3	-3975	-3895	68.2	-3990	-3815	95.4		95.4			100
R_Date UBA-33721	-3956	-3801	68.2	-3979	-3714	95.4	-3916	-3793	68.2	-3959	-3717	95.4		103.4			99.9
R_Combine 469cm	-3634	-3531	68.2	-3639	-3523	95.4	-3636	-3531	68.2	-3640	-3524	95.4		96.8			100
R_Date UBA-22425	-3627	-3378	68.2	-3633	-3373	95.4	-3538	-3387	68.2	-3627	-3377	95.4		94.9			99.9
R_Combine 431cm	-3330	-3105	68.2	-3339	-3097	95.4	-3327	-3101	68.2	-3337	-3096	95.4		98.4			98
Boundary top of profile							-3299	-3086	68.1	-3344	-2875	95.4					94.5

Table C.13 OxCal P_Sequence model for Lough Cullin (LC) with radiocarbon date SUERC-70843 included

C.2.2. OxCal *P_Sequence* model for Lough Cullin (LC) with radiocarbon date SUERC-70843 excluded

```
Plot(“LC with SUERC-70843 excluded”)
 {
  P_Sequence("LC",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=625;
   };
   R_Date("UBA-22427", 9057, 48)
   {
    z=621;
   };
   Date("617")
   {
    z=617;
   };
   Date("LC1")
   {
    z=603;
   };
   Date("597")
   {
    z=597;
   };
   Date("595")
   {
    z=595;
   };
   Date("593")
   {
    z=593;
   };
   R_Date("UB-30918", 7358, 37)
   {
    z=591;
   };
   Date("589")
   {
    z=589;
   };
   Date("LC2")
   {
    z=588;
   };
   Date("587")
   {
    z=587;
```

```
};
Date("581")
{
 z=581;
};
Date("575")
{
 z=575;
};
Date("548")
{
 z=548;
};
R_Date("UBA-22426", 6154, 47)
{
 z=546;
};
R_Date("SUERC-70844", 5788, 26)
{
 z=534;
};
Date("520")
{
 z=520;
};
Date("LC3")
{
 z=519;
};
Date("518")
{
 z=518;
};
Date("516")
{
 z=516;
};
Date("512")
{
 z=512;
};
Date("510")
{
 z=510;
};
Date("LC4")
{
 z=509;
};
Date("Elm Decline")
```

```
{
 z=508;
};
Date("Start Landnam")
{
 z=506;
};
Date("Begin Plantago")
{
 z=504;
};
Date("502")
{
 z=502;
};
R_Date("UBA-30917", 5210, 34)
{
 z=501;
};
Date("499")
{
 z=499;
};
R_Date("UBA-33722", 5076, 51)
{
 z=497;
};
Date("495")
{
 z=495;
};
Date("Peak Plantago & Landnam")
{
 z=491;
};
R_Date("UBA-33721", 5080, 56)
{
 z=487;
};
Date("1st Cultivation")
{
 z=485;
};
Date("LC5b")
{
 z=484;
};
Date("End Landnam")
{
 z=483;
```

```
};
Date("479")
{
 z=479;
};
Date("477")
{
 z=477;
};
Date("Second Cultivation")
{
 z=475;
};
Date("473")
{
 z=473;
};
Date("471")
{
 z=471;
};
R_Combine("LC469cm")
{
 z=469;
 R_Date("SUERC-70841", 4755, 29);
 R_Date("SUERC-70842", 4795, 26);
};
Date("Elm Recovery & End Plantago")
{
 z=467;
};
Date("463")
{
 z=463;
};
R_Date("UBA-22425", 4710, 39)
{
 z=460;
};
Date("457")
{
 z=457;
};
Date("LC6")
{
 z=438;
};
Date("Second Elm Decline")
{
 z=437;
```

```
};
Date("433")
{
 z=433;
};
R_Combine("LC431cm")
{
 z=431;
 R_Date("SUERC-70836", 4459, 29);
 R_Date("SUERC-70837", 4520, 27);
};
Date("429")
{
 z=429;
};
Date("3rd Cultivation")
{
 z=426;
};
Date("418")
{
 z=418;
};
Date("410")
{
 z=410;
};
Date("LC7")
{
 z=408;
};
Date("4th Cultivation")
{
 z=402;
};
Date("394")
{
 z=394;
};
Date("LC8")
{
 z=390;
};
R_Date("UBA-22424", 3800, 36)
{
 z=379;
};
Boundary(t)
{
 z=378;
```

```
 };
};
Difference("", "Elm Recovery & End Plantago", "Elm Decline");
Difference("", "Second Elm Decline", "Elm Recovery & End Plantago");
Difference("", "Begin Plantago", "Elm Decline");
Difference("", "Elm Recovery & End Plantago", "Begin Plantago");
Difference("", "End Landnam", "Start Landnam");
Difference("", "1st Cultivation", "Start Landnam");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 94.1 Aoverall 94.4				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
LC (1,0.01,U(-2,2))	-2	2	68.2	-2	2	95.4	-0.64185	-0.54585	68.2	-0.64185	-0.46585	95.4		100			99.9
b							-8422	-8250	68.2	-8575	-8001	95.4					99.4
UBA-22427 (9057,48)	-8295	-8248	68.2	-8422	-8208	95.4	-8296	-8239	68.2	-8329	-7976	95.5		88.5			99.9
617							-8267	-7881	68.2	-8295	-7469	95.4					99.7
LC1							-7341	-6655	68.2	-7693	-6429	95.4					99.7
597							-6816	-6316	68.2	-7224	-6204	95.4					99.6
595							-6623	-6235	68.2	-7006	-6136	95.4					99.8
593							-6467	-6211	68.2	-6762	-6105	95.4					99.8
UB-30918 (7358,37)	-6339	-6106	68.2	-6360	-6091	95.4	-6360	-6128	68.2	-6371	-6106	95.4		97			99.8
589							-6334	-6116	68.2	-6365	-6018	95.4					99.6
LC2							-6322	-6091	68.2	-6357	-5971	95.4					99.5
587							-6272	-6056	68.2	-6346	-5922	95.4					99.5
581							-6166	-5877	68.2	-6267	-5698	95.4					99.9
575							-6021	-5687	68.2	-6150	-5510	95.4					99.8
548							-5214	-5039	68.2	-5330	-4964	95.4					99.6
UBA-22426 (6154,47)	-5207	-5048	68.2	-5221	-4961	95.4	-5150	-5003	68.2	-5214	-4962	95.4		97.3			99.7
SUERC-70844 (5788,26)	-4691	-4605	68.2	-4710	-4555	95.4	-4696	-4619	68.2	-4717	-4567	95.4		102.9			99.9
520							-4492	-4273	68.2	-4577	-4168	95.4					99.2
LC3							-4470	-4250	68.2	-4559	-4150	95.4					99.1
518							-4449	-4227	68.2	-4542	-4132	95.4					99.3
516							-4402	-4183	68.2	-4506	-4097	95.4					99.5
512							-4304	-4101	68.2	-4418	-4037	95.4					99.4
510							-4251	-4066	68.2	-4370	-4014	95.4					99.1
LC4							-4226	-4047	68.2	-4346	-4003	95.4					99.1

Elm Decline							-4199	-4032	68.2	-4319	-3993	95.4					99.3
Start Landnam							-4143	-4005	68.2	-4264	-3978	95.4					99.8
Begin Plantago							-4088	-3985	68.2	-4202	-3967	95.4					99.9
502							-4043	-3977	68.2	-4121	-3959	95.4					99.9
UBA-30917 (5210,34)	-4041	-3976	68.2	-4221	-3958	95.4	-4035	-3972	68.2	-4049	-3961	95.4		105.8			99.9
499							-4003	-3936	68.2	-4041	-3891	95.4					99.9
UBA-33722 (5076,51)	-3953	-3801	68.2	-3975	-3715	95.3	-3968	-3911	68.2	-3988	-3850	95.4		96.1			99.9
495							-3959	-3886	68.2	-3977	-3826	95.4					99.9
Peak Plantago & Landnam							-3922	-3832	68.2	-3956	-3785	95.4					99.9
UBA-33721 (5080,56)	-3956	-3801	68.2	-3979	-3714	95.4	-3877	-3792	68.2	-3929	-3731	95.4		103.4			99.9
1st Cultivation							-3862	-3760	68.2	-3911	-3696	95.4					99.7
LC5b							-3852	-3741	68.2	-3901	-3676	95.4					99.6
End Landnam							-3839	-3723	68.2	-3890	-3657	95.4					99.7
479							-3782	-3656	68.2	-3840	-3598	95.4					99.9
477							-3750	-3624	68.2	-3810	-3575	95.4					99.9
Second Cultivation							-3711	-3592	68.2	-3779	-3556	95.4					99.9
473							-3673	-3570	68.2	-3740	-3539	95.4					99.9
471							-3646	-3551	68.2	-3694	-3529	95.4					99.9
LC469cm (4777,20)	-3634	-3531	68.2	-3639	-3523	95.4	-3636	-3534	68.2	-3640	-3525	95.4		97.9			99.9
Elm Recovery & End Plantago							-3631	-3519	68.2	-3637	-3482	95.4					99.9
463							-3561	-3455	68.2	-3618	-3412	95.4					99.9
UBA-22425 (4710,39)	-3627	-3378	68.2	-3633	-3373	95.4	-3532	-3407	68.2	-3596	-3376	95.3		96.7			99.9
457							-3515	-3381	68.2	-3575	-3327	95.4					99.8
LC6							-3302	-3161	68.2	-3376	-3121	95.4					99.5
Second Elm Decline							-3287	-3148	68.2	-3365	-3114	95.4					99.6
433							-3238	-3106	68.2	-3326	-3097	95.4					99.8
LC431cm (4492,20)	-3330	-3105	68.2	-3339	-3097	95.4	-3226	-3097	68.2	-3306	-3091	95.4		95			99.9
429							-3221	-3065	68.2	-3297	-2990	95.4					99.9
3rd Cultivation							-3168	-3000	68.2	-3266	-2892	95.4					99.9

418							-3061	-2832	68.2	-3157	-2695	95.4					99.9
410							-2926	-2666	68.2	-3038	-2535	95.4					99.7
LC7							-2891	-2627	68.2	-3008	-2498	95.4					99.8
4th Cultivation							-2774	-2511	68.2	-2905	-2395	95.4					99.9
394							-2611	-2368	68.2	-2750	-2274	95.4					99.8
LC8							-2525	-2305	68.2	-2667	-2221	95.4					99.8
UBA-22424 (3800,36)	-2291	-2150	68.2	-2431	-2064	95.3	-2288	-2150	68.2	-2400	-2061	95.3		100.9			99
t							-2284	-2141	68.2	-2401	-2036	95.4					97
Elm Recovery & End Plantago,Elm Decline							472	660	68.2	411	787	95.4					99.6
Second Elm Decline,Elm Recovery & End Plantago							256	402	68.2	181	460	95.4					99.9
Begin Plantago,Elm Decline							-2	96	68.2	-2	219	95.4					99.9
Elm Recovery & End Plantago,Begin Plantago							421	561	68.2	366	669	95.4					99.8
End Landnam,Start Landnam							215	400	68.2	147	526	95.4					99.7
1st Cultivation,Start Landnam							190	368	68.2	126	494	95.4					99.7

Table C.14 OxCal P_Sequence model for Lough Cullin (LC) with radiocarbon date SUERC-70843 excluded

C.2.3. OxCal *P_Sequence* Outlier (0.05) model for Lough Cullin (LC)

```
Plot("Lough Cullin Outlier Model)
 {
  Outlier_Model("General",T(5),U(0,4),"t");
  P_Sequence("",1,0.1,U(-2,2))
  {
   Boundary();
   R_Date("UBA-22427",9057,48)
   {
    Outlier(0.05);
    z=621;
   };
   R_Date("UBA-30918",7358,37)
   {
    Outlier(0.05);
    z=591;
   };
   R_Date("UBA-22426",6154,47)
   {
    Outlier(0.05);
    z=546;
   };
   R_Date("SUERC-70844",5788,26)
   {
    Outlier(0.05);
    z=534;
   };
   R_Date("UBA-30917",5210,34)
   {
    Outlier(0.05);
    z=501;
   };
   R_Date("UBA-33722",5076,51)
   {
    Outlier(0.05);
    z=497;
   };
   R_Date("UBA-33721",5080,56)
   {
    Outlier(0.05);
    z=487;
   };
   R_Combine("469cm")
   {
    z=469;
    Outlier(0.05);
    R_Date("SUERC-70841", 4755, 29);
    R_Date("SUERC-70842", 4795, 26);
   };
```

```
  R_Date("UBA-22425",4710,39)
  {
   Outlier(0.05);
   z=460;
  };
  R_Combine("431cm")
  {
   z=431;
   Outlier(0.05);
   R_Date("SUERC-70836", 4459, 29);
   R_Date("SUERC-70837", 4520, 27);
  };
  Boundary();
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 100.3 Aoveral l 100.1				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Outlier_Model General							-41	40	68.2	-237	193	95.4					99.7
T(5)	-1.135	1.135	68.2	-2.65	2.65	95.4											95.2
U(0,4)	3.99E-17	4	68.2	3.99E-17	4	95.4	5.38E-17	2.408	68.2	5.38E-17	4	95.4		100			99.3
P_Sequence(1,0.6,U(-2,2))	-2	2	68.2	-2	2	95.4	-1.27651	-0.95651	68.2	-1.34451	-0.76851	95.4		100			99.3
Boundary							-8295	-8245	68.2	-8423	-7996	95.3					99.6
R_Date UBA-22427	-8295	-8248	68.2	-8422	-8208	95.4	-8295	-8245	68.2	-8423	-7996	95.3		98.9		95.6	99.6
R_Date UBA-30918	-6339	-6106	68.2	-6360	-6091	95.4	-6347	-6109	68.2	-6364	-6095	95.4		100.7		96.3	99.5
R_Date UBA-22426	-5207	-5048	68.2	-5221	-4961	95.4	-5193	-5022	68.2	-5219	-4955	95.4		99.1		96	99.6
R_Date SUERC-70844	-4691	-4605	68.2	-4710	-4555	95.4	-4694	-4611	68.2	-4713	-4558	95.4		102.9		96.6	99.8
R_Date UBA-30917	-4041	-3976	68.2	-4221	-3958	95.4	-4036	-3968	68.2	-4055	-3953	95.4		103.7		96.3	99.6
R_Date UBA-33722	-3953	-3801	68.2	-3975	-3715	95.3	-3976	-3893	68.2	-3991	-3811	95.4		96.5		96.2	99.8
R_Date UBA-33721	-3956	-3801	68.2	-3979	-3714	95.4	-3920	-3794	68.2	-3961	-3716	95.4		105.2		96.6	99.7
R_Combine 469cm	-3634	-3531	68.2	-3639	-3523	95.4	-3636	-3531	68.2	-3640	-3523	95.4		98.4		96.7	99.7
R_Date UBA-22425	-3627	-3378	68.2	-3633	-3373	95.4	-3538	-3384	68.2	-3628	-3376	95.4		96.2		96.7	99.6
R_Combine 431cm	-3330	-3105	68.2	-3339	-3097	95.4	-3297	-3099	68.2	-3335	-3095	95.4		99.2		96.3	99.7
Boundary							-3297	-3099	68.2	-3335	-3095	95.4					99.7

Table C.15 OxCal P_Sequence Outlier (0.05) model for Lough Cullin (LC) with radiocarbon date SUERC-70843 excluded

Element	Ok	Outlier	Prior	Posterior	Model	Type
UBA-22427			5	5	General	t
UBA-30918			5	4	General	t
UBA-22426			5	4	General	t
SUERC-70844			5	4	General	t
UBA-30917			5	4	General	t
UBA-33722			5	4	General	t
UBA-33721			5	3	General	t
469cm			5	3	General	t
UBA-22425			5	3	General	t
431cm			5	4	General	t

Figure C.2 OxCal P_Sequence Outlier (0.05) model for Lough Cullin (LC) with radiocarbon date SUERC-70843 excluded

C.2.4. OxCal *P_Sequence* Deposition model for Lough Cullin (LC)

```
Plot()
 {
  P_Sequence("LC",1,1,U(-2,2))
  {
   Boundary(b)
   {
    z=625;
   };
   R_Date("UBA_22427", 9057, 48)
   {
    z=621;
   };
   R_Date("UB_30918", 7358, 37)
   {
    z=591;
   };
   R_Date("UBA_22426", 6154, 47)
   {
    z=545;
   };
   R_Date("SUERC_70844", 5788, 26)
   {
    z=533;
   };
   R_Date("UBA_30917", 5210, 34)
   {
    z=501;
   };
   R_Date("UBA_33722", 5076, 51)
   {
    z=497;
   };
   R_Date("UBA_33721", 5080, 56)
   {
    z=487;
   };
   R_Date("SUERC_70841", 4755, 29)
   {
    z=469;
   };
   R_Date("UBA_22425", 4710, 39)
   {
    z=460;
   };
   R_Date("SUERC_70836", 4459, 29)
   {
    z=431;
   };
```

```
 R_Date("UBA_22424", 3800, 36)
 {
  z=379;
 };
 Boundary(t)
 {
  z=378;
 };
};
DT=(UBA_22424-UBA_22427)/242;
DR=242/(UBA_22424-UBA_22427);
Difference("span", "t", "b");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 98.1 Aoveral 198.5				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence LC	-2	2	68.2	-2	2	95.4	-1.19752	-0.86952	68.2	-1.30952	-0.71352	95.4		100			99.4
Boundary b							-8373	-8236	68.2	-8686	-7995	95.4					99
R_Date UBA_22427	-8295	-8248	68.2	-8422	-8208	95.4	-8294	-8245	68.2	-8343	-7990	95.4		95.9			99.7
R_Date UB_30918	-6339	-6106	68.2	-6360	-6091	95.4	-6348	-6110	68.1	-6364	-6096	95.4		99.4			99.9
R_Date UBA_22426	-5207	-5048	68.2	-5221	-4961	95.4	-5194	-5018	68.2	-5217	-4962	95.4		97.9			99.9
R_Date SUERC_70844	-4691	-4605	68.2	-4710	-4555	95.4	-4694	-4612	68.2	-4713	-4559	95.4		101.3			100
R_Date UBA_30917	-4041	-3976	68.2	-4221	-3958	95.4	-4036	-3969	68.2	-4052	-3957	95.4		102.6			99.9
R_Date UBA_33722	-3953	-3801	68.2	-3975	-3715	95.3	-3975	-3895	68.2	-3990	-3815	95.4		95.3			100
R_Date UBA_33721	-3956	-3801	68.2	-3979	-3714	95.4	-3916	-3793	68.2	-3960	-3717	95.4		103.5			99.9
R_Date SUERC_70841	-3633	-3521	68.2	-3638	-3383	95.4	-3633	-3525	68.2	-3640	-3513	95.4		105.8			100
R_Date UBA_22425	-3627	-3378	68.2	-3633	-3373	95.4	-3596	-3381	68.2	-3626	-3374	95.3		96.3			99.9
R_Date SUERC_70836	-3323	-3030	68.1	-3336	-3021	95.5	-3308	-3028	68.2	-3331	-3020	95.5		97.9			99.9
R_Date UBA_22424	-2291	-2150	68.2	-2431	-2064	95.3	-2292	-2151	68.2	-2434	-2134	95.4		99.3			97.2
Boundary t							-2292	-2144	68.2	-2449	-2034	95.5					96.2
DT	24.6756	25.2521	68.2	24.1467	25.6219	95.4	24.6488	25.2417	68.2	23.8202	25.5909	95.4					99
(UBA_22424-UBA_22427)	5972	6111	68.2	5844	6201	95.4	5965	6109	68.2	5765	6193	95.4					99
=UBA_22424	-2291	-2150	68.2	-2431	-2064	95.3	-2292	-2151	68.2	-2434	-2134	95.4					97.2
=UBA_22427	-8295	-8248	68.2	-8422	-8208	95.4	-8294	-8245	68.2	-8343	-7990	95.4					99.7
242							241.5	242.5	68.2	241.5	242.5	95.4					100
DR	0.0396	0.040514	68.2	0.038978	0.041363	95.4	0.039594	0.040565	68.2	0.039009	0.041773	95.4					98.9
242							241.5	242.5	68.2	241.5	242.5	95.4					100

(UBA_22424-UBA_22427)	5972	6111	68.2	5844	6201	95.4	5965	6109	68.2	5765	6193	95.4					99
=UBA_22424	-2291	-2150	68.2	-2431	-2064	95.3	-2292	-2151	68.2	-2434	-2134	95.4					97.2
=UBA_22427	-8295	-8248	68.2	-8422	-8208	95.4	-8294	-8245	68.2	-8343	-7990	95.4					99.7
Difference span							5959	6211	68.2	5762	6521	95.4					97.8

Table C.16 OxCal P_Sequence Deposition model for Lough Cullin (LC) with humin fraction derived radiocarbon dates

C.3. Bayesian and *P_Sequence* Models outlined in Chapter 6

C.3.1. OxCal *P_Sequence* model for Arderawinny (ARD) with radiocarbon date UBA-33012 included

```
Plot(“ARD P_Sequence with UBA-33012 included”)
 {
  P_Sequence("ARD",1,0.01,U(-2,2))
  {
   Boundary(“base of profile”)
   {
    z=512;
   };
   R_Combine(“444cm”)
   {
    z=444;
    R_Date("UBA-36370", 8059, 38);
    R_Date("UBA-36371", 8051, 47);
   };
   R_Combine(“417cm”)
   {
    z=417;
    R_Date("UBA-33012", 6788, 49);
    R_Date("UBA-33013", 6642, 37)
    {
    };
   };
   R_Combine(“364cm”)
   {
    z=364;
    R_Date("UBA-36368", 5207, 32);
    R_Date("UBA-36369", 5139, 34);
   };
   R_Date("UBA-33011", 5031, 32)
   {
    z=342;
   };
   R_Date("UBA-33720", 4817, 44)
   {
    z=321;
   };
   R_Date("UBA-33279", 4450, 47)
   {
    z=294;
   };
   R_Combine("230cm")
   {
    z=230;
    R_Date("UBA-33280", 4017, 33);
```

```
  R_Date("UBA-33281", 3933, 32);
 };
 R_Date("UBA-35534", 3237, 28)
 {
  z=94;
 };
 Boundary("top of profile")
 {
  z=40;
 };
};
};
```

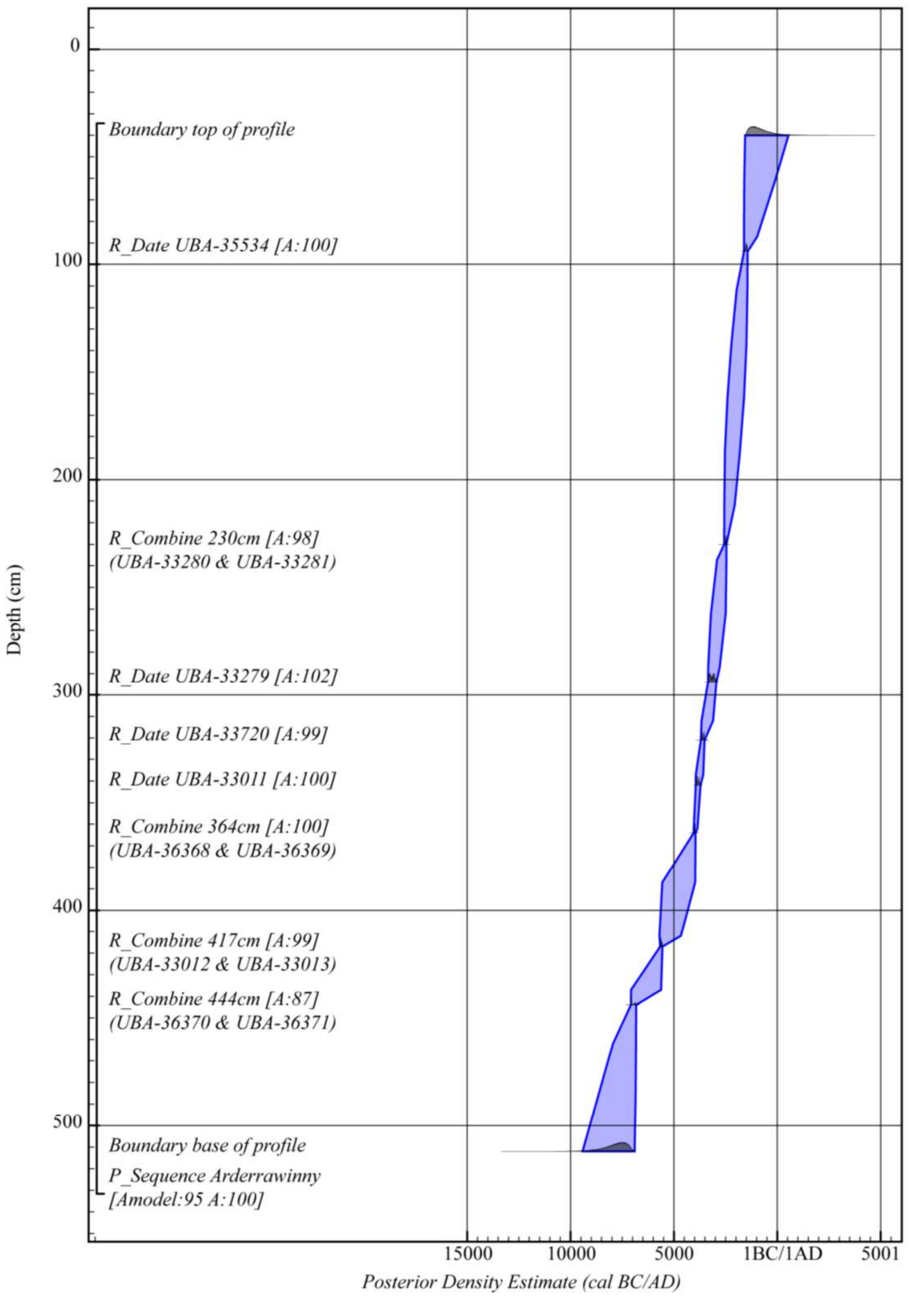

Figure C.3 Bayesian age-model of the chronology of the sediment sequence at Arderrawinny (P_Sequence model (k=0.01-100) (Bronk Ramsey, 2008; Bronk Ramsey and Lee, 2013) with UBA-33012 included. Blue band showing the estimated date of sediment at the corresponding depth at 95.4% probability

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 94.7 Aoverall 94.6				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Boundary top of profile							-1454	-584	68.2	-1558	542	95.4					96.9
R_Date UBA-35534	-1595	-1452	68.2	-1609	-1438	95.4	-1532	-1451	68.2	-1608	-1437	95.4		99.9			99.9
R_Combine 230cm	-2559	-2469	68.2	-2570	-2462	95.4	-2561	-2469	68.2	-2570	-2462	95.4		97.9			99.8
R_Date UBA-33279	-3327	-3023	68.3	-3339	-2931	95.4	-3332	-3030	68.3	-3349	-2945	95.5		101.6			99.8
R_Date UBA-33720	-3652	-3531	68.2	-3696	-3518	95.4	-3653	-3531	68.2	-3696	-3519	95.4		99.2			99.8
R_Date UBA-33011	-3938	-3775	68.2	-3946	-3714	95.4	-3939	-3775	68.2	-3947	-3715	95.4		99.5			99.9
R_Combine 364cm	-4033	-3962	68.2	-4041	-3955	95.4	-4032	-3961	68.2	-4040	-3955	95.4		100.2			99.9
R_Combine 417cm	-5641	-5567	68.2	-5666	-5557	95.4	-5642	-5568	68.2	-5666	-5557	95.4		99			99.9
Warning! X-Test fails at 5% - X2-Test: df=1 T=5.682(5% 3.8)																	
R_Combine 444cm	-7074	-6864	68.2	-7083	-6830	95.4	-7072	-6849	68.2	-7081	-6827	95.4		87			99.7
Boundary base of profile							-8199	-7111	68.2	-9423	-6901	95.4					97.2
P_Sequence ARD	-2	2	68.2	-2	2	95.4	-1.6517	-1.2837	68.2	-1.7397	-1.1077	95.4		100			99.8

Table C.17 OxCal P_Sequence model for Arderawinny (ARD) with radiocarbon date UBA-33012 included

C.3.2. OxCal *P_Sequence* model for Arderawinny (ARD) with radiocarbon date UBA-33012 excluded

```
Plot(“ARD P_Sequence with UBA-33012 excluded”)
 {
  P_Sequence("ARD",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=512;
   };
   Date("456")
   {
    z=456;
   };
   Date("ARD1a")
   {
    z=450;
   };
   R_Combine("ARD 444cm")
   {
    z=444;
    R_Date("UBA-36370", 8059, 38);
    R_Date("UBA-36371", 8051, 47);
   };
   Date("440")
   {
    z=440;
   };
   Date("ARD1b")
   {
    z=438;
   };
   Date("436")
   {
    z=436;
   };
   R_Date("UBA-33013", 6642, 37)
   {
    z=417;
   };
   Date("1st Cereal")
   {
    z=416;
   };
   Date("396")
   {
    z=396;
   };
   Date("ARD2")
```

```
{
 z=394;
};
Date("Begin Plantago")
{
 z=380;
};
Date("ARD3")
{
 z=371;
};
R_Combine("ARD 364cm")
{
 z=364;
 R_Date("UBA-36368", 5207, 37);
 R_Date("UBA-36369", 5139, 34);
};
Date("360")
{
 z=360;
};
Date("Pre-ED Peak Plantago")
{
 z=344;
};
R_Date("UBA-33011", 5031, 32)
{
 z=342;
};
Date("340")
{
 z=340;
};
Date("Elm Decline")
{
 z=338;
};
Date("ARD4")
{
 z=337;
};
Date("332")
{
 z=332;
};
Date("Post-ED Peak Plantago")
{
 z=326;
};
Date("ARD5")
```

```
{
 z=323;
};
Date("322")
{
 z=322;
};
R_Date("UBA-33720", 4817, 44)
{
 z=321;
};
Date("316")
{
 z=316;
};
Date("ARD6")
{
 z=311;
};
Date("310")
{
 z=310;
};
Date("End Plantago")
{
 z=302;
};
R_Date("UBA-33279", 4450, 47)
{
 z=294;
};
Date("278")
{
 z=278;
};
Date("ARD7")
{
 z=274;
};
Date("256")
{
 z=256;
};
Date("ARD8")
{
 z=242;
};
Date("240")
{
 z=240;
```

```
 };
 Date("236")
 {
  z=236;
 };
 R_Combine("ARD 230cm")
 {
  z=230;
  R_Date("UBA-33280", 4017, 33);
  R_Date("UBA-33281", 3933, 32);
 };
 Date("ARD9")
 {
  z=218;
 };
 Date("216")
 {
  z=216;
 };
 Date("212")
 {
  z=212;
 };
 Date("ARD10")
 {
  z=186;
 };
 Date("174")
 {
  z=174;
 };
 Date("ARD11a")
 {
  z=146;
 };
 Date("ARD11b")
 {
  z=114;
 };
 R_Date("UBA-35594", 3237, 28)
 {
  z=94;
 };
 Boundary(t)
 {
  z=40;
 };
};
Difference("", "Begin Plantago", "Elm Decline");
Difference("", "Elm Decline", "Post-ED Peak Plantago");
```

```
 Difference("", "322", "Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 88.7 Aoverall 88.9				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
ARD (1,0.04,U(-2,2))	-2	2	68.2	-2	2	95.4	-1.04073	-0.93273	68.2	-1.04073	-0.83273	95.4		100			99.2
b							-8255	-7469	68.2	-8879	-7224	95.4					98.9
456							-7238	-6900	68.2	-7515	-6848	95.4					99.6
ARD1a							-7143	-6854	68.2	-7335	-6832	95.4					99.8
ARD 444cm (8056,30)	-7074	-6864	68.2	-7083	-6830	95.4	-7070	-6842	68.1	-7080	-6825	95.4		73			99.8
440							-7065	-6716	68.2	-7076	-6179	95.4					98.3
ARD1b							-7058	-6562	68.2	-7070	-6020	95.4					95.6
436							-7044	-6369	68.2	-7061	-5915	95.4					95.5
UBA-33013 (6642,37)	-5620	-5550	68.2	-5633	-5511	95.4	-5621	-5551	68.2	-5634	-5511	95.4		100.3			99.4
1st Cereal							-5620	-5530	68.2	-5642	-5344	95.4					99.1
396							-5302	-4630	68.2	-5483	-4365	95.4					95.9
ARD2							-5223	-4580	68.2	-5452	-4314	95.4					96.2
Begin Plantago							-4641	-4090	68.2	-5013	-4000	95.4					99.8
ARD3							-4251	-3968	68.2	-4647	-3957	95.4					99.9
ARD 364cm (5170,26)	-4032	-3959	68.2	-4041	-3951	95.4	-4035	-3961	68.2	-4041	-3953	95.4		94.9			99.9
360							-4031	-3932	68.2	-4040	-3869	95.4					99.9
Pre-ED Peak Plantago							-3929	-3776	68.2	-3948	-3721	95.4					98.2
UBA-33011 (5031,32)	-3938	-3775	68.2	-3946	-3714	95.4	-3921	-3767	68.2	-3937	-3715	95.4		97.3			97.9
340							-3908	-3750	68.2	-3936	-3691	95.4					97.4
Elm Decline							-3891	-3708	68.2	-3927	-3648	95.4					96.4
ARD4							-3884	-3701	68.2	-3921	-3628	95.4					97.1
332							-3798	-3632	68.2	-3879	-3565	95.4					99.3
Post-ED Peak Plantago							-3696	-3552	68.2	-3803	-3528	95.4					99.5
ARD5							-3662	-3536	68.2	-3746	-3521	95.4					98.8

322							-3656	-3534	68.2	-3714	-3518	95.4					98.7
UBA-33720 (4817,44)	-3652	-3531	68.2	-3696	-3518	95.4	-3651	-3532	68.2	-3693	-3519	95.4		101.8			99
316							-3642	-3471	68.2	-3666	-3316	95.4					99.1
ARD6							-3569	-3358	68.2	-3644	-3223	95.4					94.9
310							-3558	-3342	68.2	-3636	-3202	95.4					95.6
End Plantago							-3452	-3221	68.2	-3536	-3071	95.4					99.5
UBA-33279 (4450,47)	-3327	-3023	68.3	-3339	-2931	95.4	-3335	-3085	68.2	-3347	-3022	95.4		103			99.8
278							-3186	-2912	68.2	-3274	-2781	95.4					99.6
ARD7							-3134	-2856	68.2	-3243	-2733	95.4					99.5
256							-2903	-2642	68.2	-3054	-2559	95.4					99.8
ARD8							-2711	-2526	68.2	-2852	-2478	95.4					99.3
240							-2677	-2500	68.2	-2819	-2473	95.4					99.1
236							-2611	-2478	68.2	-2752	-2466	95.4					99.6
ARD 230cm (3974,23)	-2559	-2469	68.2	-2570	-2462	95.4	-2561	-2471	68.2	-2570	-2463	95.4		97.3			99.8
ARD9							-2531	-2386	68.2	-2558	-2267	95.4					99.3
216							-2520	-2363	68.2	-2553	-2241	95.4					99.2
212							-2493	-2319	68.2	-2543	-2195	95.4					99.6
ARD10							-2329	-2080	68.2	-2420	-1939	95.4					99.9
174							-2238	-1975	68.2	-2347	-1842	95.4					99.9
ARD11a							-2009	-1747	68.2	-2142	-1642	95.4					99.9
ARD11b							-1712	-1531	68.2	-1845	-1480	95.4					99.9
UBA-35594 (3237,28)	-1595	-1452	68.2	-1609	-1438	95.4	-1528	-1451	68.2	-1604	-1433	95.4		101.9			100
t							-1135	-474	68.2	-1317	69	95.4					99.4
Begin Plantago,Elm Decline							-884	-310	68.2	-1263	-181	95.4					99.7
Elm Decline,Post-ED Peak Plantago							-195	-29	68.2	-294	-1	95.4					98.3
322,Elm Decline							92	266	68.2	30	343	95.4					93.8

Table C.18 OxCal P_Sequence model for Arderawinny (ARD) with radiocarbon date UBA-33012 excluded

C.3.3. OxCal *P_Sequence* Outlier (0.05) model for Arderawinny (ARD)

```
Plot(“ARD outlier model”)
 {
  Outlier_Model("General",T(5),U(0,4),"t");
  P_Sequence("ARD",1,0.01,U(-2,2))
  {
   Boundary();
   R_Combine("444cm")
   {
    R_Date("UBA-36371",8051,47);
    R_Date("UBA-36370",8059,38);
    Outlier(0.05);
    z=444;
   };
   R_Date("UBA-33013",6642,37)
   {
    Outlier(0.05);
    z=417;
   };
   R_Combine("364cm")
   {
    R_Date("UBA-36369",5139,34);
    R_Date("UBA-36368",5207,37);
    Outlier(0.05);
    z=364;
   };
   R_Date("UBA-33011",5031,32)
   {
    Outlier(0.05);
    z=342;
   };
   R_Date("UBA-33720",4817,44)
   {
    Outlier(0.05);
    z=321;
   };
   R_Date("UBA-33279",4450,47)
   {
    Outlier(0.05);
    z=294;
   };
   R_Combine("230cm")
   {
    R_Date("UBA-33281",3933,32);
    R_Date("UBA-33280",4017,33);
    Outlier(0.05);
    z=230;
   };
   R_Date("UBA-35534",3237,28)
```

```
  {
   Outlier(0.05);
   z=94;
  };
  Boundary();
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 99.4 Aoveral l 99				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Outlier_Model General							-49	49	68.2	-265	277	95.4					99.9
T(5)	-1.135	1.135	68.2	-2.65	2.65	95.4											96.1
U(0,4)	3.99E-17	4	68.2	3.99E-17	4	95.4	5.38E-17	2.452	68.2	5.38E-17	3.84	95.4		100			97.9
P_Sequence(1,0.04,U(-2,2))	-2	2	68.2	-2	2	95.4	-1.64297	-1.27097	68.2	-1.71897	-1.10297	95.4		100			99.9
Boundary							-7073	-6850	68.2	-7082	-6827	95.4					99.8
R_Combine UBA-36371/UBA-36370	-7074	-6864	68.2	-7083	-6830	95.4	-7073	-6850	68.2	-7082	-6827	95.4		90		96	99.8
R_Date UBA-33013	-5620	-5550	68.2	-5633	-5511	95.4	-5621	-5549	68.2	-5635	-5496	95.4		100.9		96	99.6
R_Combine UBA-36369/UBA-36368	-4032	-3959	68.2	-4041	-3951	95.4	-3991	-3958	68.2	-4041	-3949	95.4		101.7		96	99.8
R_Date UBA-33011	-3938	-3775	68.2	-3946	-3714	95.4	-3939	-3774	68.2	-3947	-3714	95.4		100.9		96.6	99.9
R_Date UBA-33720	-3652	-3531	68.2	-3696	-3518	95.4	-3653	-3531	68.2	-3701	-3517	95.4		100.6		96.3	99.9
R_Date UBA-33279	-3327	-3023	68.3	-3339	-2931	95.4	-3333	-3030	68.2	-3349	-2945	95.4		102.8		96.1	99.8
R_Combine UBA-33281/UBA-33280	-2559	-2469	68.2	-2570	-2462	95.4	-2561	-2469	68.2	-2571	-2461	95.4		99.3		96.3	99.8
R_Date UBA-35534	-1595	-1452	68.2	-1609	-1438	95.4	-1531	-1451	68.2	-1608	-1436	95.4		101.2		96.4	99.9
Boundary							-1531	-1451	68.2	-1608	-1436	95.4					99.9

Table C.19 OxCal P_Sequence Outlier (0.05) model for Arderawinny (ARD) with radiocarbon date UBA-33012 excluded

Element	Ok	Outlier	Prior	Posterior	Model	Type
UBA-36371/UBA-36370			5	4	General	t
UBA-33013			5	4	General	t
UBA-36369/UBA-36368			5	4	General	t
UBA-33011			5	3	General	t
UBA-33720			5	4	General	t
UBA-33279			5	4	General	t
UBA-33281/UBA-33280			5	4	General	t
UBA-35534			5	4	General	t

Figure C.4 OxCal P_Sequence Outlier (0.05) model for Arderawinny (ARD) with radiocarbon date UBA-33012 excluded

C.3.4. OxCal *P_Sequence* Deposition model for Arderawinny (ARD)

```
Plot("ARD Deposition Model")
 {
  P_Sequence("ARD",1,1,U(-2,2))
  {
   Boundary("base of profile")
   {
    z=512;
   };
   R_Date("UBA_36371", 8051, 47)
   {
    z=444;
   };
   R_Date("UBA_33013", 6742, 37)
   {
    z=417;
   };
   R_Date("UBA_36369", 5139, 34)
   {
    z=364;
   };
   R_Date("UBA_33011", 5031, 32)
   {
    z=342;
   };
   R_Date("UBA_33720", 4817, 44)
   {
    z=321;
   };
   R_Date("UBA_33279", 4450, 47)
   {
    z=294;
   };
   R_Date("UBA_33280", 4017, 33)
   {
    z=230;
   };
   R_Date("UBA_35594", 3237, 28)
   {
    z=94;
   };
   Boundary("top of profile")
   {
    z=40;
   };
  };
  DT=(UBA_35594-UBA_36371)/350;
  DR=350/(UBA_35594-UBA_36371);
  Difference("span", "top of profile", "base of profile");
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 98.5 Aoverall 98				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence ARD	-2	2	68.2	-2	2	95.4	-1.6797	-1.3197	68.2	-1.7397	-1.1197	95.4		100			99.6
Boundary base of profile							-8161	-7060	68.1	-9374	-6860	95.4					98.8
R_Date UBA_36371	-7078	-6836	68.1	-7141	-6780	95.4	-7074	-6827	68.2	-7136	-6769	95.4		92.3			99.8
R_Date UBA_33013	-5701	-5624	68.2	-5721	-5573	95.4	-5702	-5625	68.2	-5721	-5574	95.4		99.4			99.8
R_Date UBA_36369	-3985	-3819	68.2	-4038	-3804	95.5	-3990	-3828	68.2	-4038	-3807	95.5		106.9			99.7
R_Date UBA_33011	-3938	-3775	68.2	-3946	-3714	95.4	-3938	-3769	68.2	-3945	-3713	95.4		96.4			99.8
R_Date UBA_33720	-3652	-3531	68.2	-3696	-3518	95.4	-3653	-3531	68.2	-3696	-3519	95.4		99			99.7
R_Date UBA_33279	-3327	-3023	68.3	-3339	-2931	95.4	-3333	-3031	68.2	-3349	-2944	95.4		101.5			99.7
R_Date UBA_33280	-2572	-2488	68.2	-2620	-2469	95.4	-2573	-2490	68.2	-2620	-2470	95.4		98.9			99.7
R_Date UBA_35594	-1595	-1452	68.2	-1609	-1438	95.4	-1531	-1452	68.2	-1608	-1438	95.4		100			99.9
Boundary top of profile							-1462	-606	68.2	-1571	507	95.4					99
DT	15.2986	15.9771	68.2	15	16.1171	95.4	15.21	15.9071	68.2	14.9571	16.0757	95.4					99.6
(UBA_35594-UBA_36371)	5355	5592	68.2	5250	5641	95.4	5324	5568	68.2	5235	5627	95.4					99.6
=UBA_35594	-1595	-1452	68.2	-1609	-1438	95.4	-1531	-1452	68.2	-1608	-1438	95.4					99.9
=UBA_36371	-7078	-6836	68.1	-7141	-6780	95.4	-7074	-6827	68.2	-7136	-6769	95.4					99.8

350							349.5	350.5	68.2	349.5	350.5	95.4					100
DR	0.062546	0.065313	68.2	0.061981	0.066633	95.4	0.062854	0.065715	68.2	0.062173	0.066843	95.4					99.6
350							349.5	350.5	68.2	349.5	350.5	95.4					100
(UBA_35594-UBA_36371)	5355	5592	68.2	5250	5641	95.4	5324	5568	68.2	5235	5627	95.4					99.6
=UBA_35594	-1595	-1452	68.2	-1609	-1438	95.4	-1531	-1452	68.2	-1608	-1438	95.4					99.9
=UBA_36371	-7078	-6836	68.1	-7141	-6780	95.4	-7074	-6827	68.2	-7136	-6769	95.4					99.8
Difference span							5885	7624	68.3	5484	9277	95.4					95

Table C.20 OxCal P_Sequence Deposition model for Arderawinny (ARD) with humin fraction derived radiocarbon dates

C.4. Bayesian and *P_Sequence* Models outlined in Chapter 7

C.4.1. Bayesian model for the start of the use at Poulnabrone – Model 3 after (Schulting 2014)

```
Plot()
 {
  Sequence("Poulnabrone Model 3")
  {
   Boundary("Start");
   Phase("Neolithic Use")
   {
    R_Date("OxA-1906", 5100, 80)
    {
     Outlier();
    };
    R_Date("OxA-25950", 5004, 31);
    R_Date("OxA-26052", 4983, 30);
    R_Date("OxA-25947", 4949, 30);
    R_Date("OxA-25948", 4937, 31);
    R_Date("OxA-25943", 4928, 30);
    R_Combine()
    {
     R_Date("OxA-22651", 4947, 30);
     R_Date("OxA-22650", 4927, 30);
    };
    R_Date("OxA-1910", 4940, 80)
    {
     Outlier();
    };
    R_Date("OxA-1905", 4930, 80)
    {
     Outlier();
    };
    R_Date("OxA-25940", 4914, 30);
    R_Date("UBA-15770", 4894, 28)
    {
     Outlier();
    };
    R_Date("OxA-25949", 4845, 29);
    R_Date("OxA-1912", 4810, 80)
    {
     Outlier();
    };
    R_Date("OxA-25942", 4799, 30);
    R_Date("OxA-25944", 4794, 30);
    R_Date("OxA-25941", 4775, 31);
    R_Date("UBA-15768", 4731, 31);
    R_Date("UBA-15769", 4728, 28);
```

```
   R_Date("OxA-1911", 4720, 70)
   {
    Outlier();
   };
   R_Date("OxA-26692", 4713, 30)
   {
    Outlier();
   };
   R_Date("OxA-26693", 4710, 28)
   {
    Outlier();
   };
   R_Date("UBA-23506", 4600, 35)
   {
    Outlier();
   };
   R_Date("OxA-25945", 4579, 29);
   R_Date("OxA-25946", 4543, 40);
   R_Date("OxA-1909", 4550, 80)
   {
    Outlier();
   };
   R_Date("OxA-1907", 4520, 80)
   {
    Outlier();
   };
   R_Date("UBA-15771", 4508, 32);
   R_Date("OxA-1908", 4440, 80)
   {
    Outlier();
   };
   R_Date("OxA-1913", 4390, 90)
   {
    Outlier();
   };
  };
  Boundary("End");
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 109.8 Aoverall 109.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Poulnabrone Model 3																	
Boundary Start							-3816	-3746	68.2	-3883	-3719	95.4					98.3
Phase Neolithic Use																	
R_Date OxA-1906	-3972	-3797	68.2	-4053	-3696	95.4	-3973	-3797	68.2	-4054	-3697	95.4				17.5	99.4
R_Date OxA-25950	-3895	-3712	68.2	-3941	-3702	95.4	-3775	-3710	68.2	-3804	-3700	95.4		107.6			99.7
R_Date OxA-26052	-3783	-3711	68.2	-3927	-3666	95.5	-3765	-3708	68.2	-3796	-3669	95.4		109.6			99.7
R_Date OxA-25947	-3766	-3672	68.2	-3786	-3656	95.4	-3758	-3670	68.2	-3776	-3656	95.4		102.5			99.9
R_Date OxA-25948	-3761	-3659	68.2	-3778	-3652	95.4	-3755	-3658	68.1	-3771	-3652	95.4		102.8			99.8
R_Date OxA-25943	-3712	-3655	68.2	-3769	-3651	95.4	-3711	-3656	68.2	-3763	-3651	95.4		102.3			99.8
R_Combine(4937,22)	-3748	-3661	68.2	-3766	-3656	95.4	-3714	-3660	68.2	-3763	-3656	95.4		101.2			99.8
R_Date OxA-1910	-3888	-3644	68.2	-3951	-3538	95.4	-3798	-3644	68.2	-3951	-3538	95.4				69.3	99.3
R_Date OxA-1905	-3795	-3641	68.2	-3947	-3536	95.4	-3795	-3641	68.2	-3946	-3536	95.4				72.9	99.6
R_Date OxA-25940	-3703	-3656	68.2	-3764	-3644	95.4	-3703	-3657	68.2	-3760	-3644	95.4		101.3			99.8
R_Date UBA-15770	-3695	-3650	68.2	-3710	-3639	95.4	-3694	-3650	68.2	-3710	-3639	95.4				99.6	99.8
R_Date OxA-25949	-3659	-3541	68.2	-3696	-3535	95.4	-3660	-3541	68.2	-3697	-3535	95.4		97.1			99.8
R_Date OxA-1912	-3694	-3386	68.3	-3763	-3373	95.4	-3693	-3386	68.2	-3763	-3373	95.4				98.4	99.4
R_Date OxA-25942	-3640	-3534	68.2	-3649	-3522	95.4	-3640	-3533	68.2	-3649	-3522	95.4		98.7			99.8
R_Date OxA-25944	-3639	-3533	68.2	-3646	-3522	95.4	-3639	-3533	68.2	-3646	-3522	95.4		99			99.5
R_Date OxA-25941	-3635	-3527	68.2	-3642	-3386	95.4	-3635	-3527	68.2	-3644	-3386	95.4		99.5			99.6
R_Date UBA-15768	-3630	-3383	68.2	-3635	-3377	95.4	-3630	-3384	68.2	-3635	-3377	95.4		99.4			99.7
R_Date UBA-15769	-3629	-3383	68.2	-3635	-3377	95.4	-3628	-3384	68.2	-3635	-3377	95.3		99.4			99.8
R_Date OxA-1911	-3631	-3378	68.2	-3638	-3370	95.4	-3631	-3378	68.2	-3638	-3370	95.4				99.3	99.4
R_Date OxA-26692	-3626	-3380	68.2	-3631	-3374	95.4	-3625	-3380	68.2	-3632	-3374	95.4				100	99.8
R_Date OxA-26693	-3623	-3380	68.2	-3631	-3374	95.4	-3623	-3380	68.2	-3631	-3373	95.3				100	99.8

R_Date UBA-23506	-3496	-3346	68.2	-3513	-3124	95.5	-3496	-3345	68.2	-3513	-3123	95.5				88.2	99.1
R_Date OxA-25945	-3486	-3143	68.3	-3497	-3118	95.4	-3482	-3341	68.2	-3498	-3195	95.5		123.7			99.8
R_Date OxA-25946	-3364	-3117	68.3	-3370	-3098	95.4	-3367	-3317	68.2	-3495	-3186	95.5		103.7			99.8
R_Date OxA-1909	-3483	-3101	68.1	-3520	-3012	95.4	-3483	-3102	68.2	-3520	-3012	95.4				42.9	99.3
R_Date OxA-1907	-3358	-3099	68.2	-3498	-2930	95.4	-3357	-3100	68.2	-3498	-2931	95.5				33.5	99.4
R_Date UBA-15771	-3340	-3110	68.2	-3352	-3097	95.4	-3356	-3307	68.2	-3365	-3209	95.4		93.3			99.3
R_Date OxA-1908	-3329	-2940	68.2	-3347	-2918	95.4	-3328	-2944	68.1	-3347	-2917	95.4				18.4	99.3
R_Date OxA-1913	-3311	-2904	68.2	-3346	-2888	95.4	-3308	-2903	68.1	-3346	-2887	95.4				12.8	99.2
Boundary End							-3342	-3259	68.2	-3354	-3135	95.4					97.9

Table C.21 Bayesian model for the start of the use at Poulnabrone – Model 3 after (Schulting, 2014)

C.4.2. Bayesian model for the start of the use at Poulnabrone – Model 4 after (Schulting 2014)

```
Plot()
 {
  Sequence("Poulnabrone Model 4")
  {
   Boundary("Start Primary");
   Phase("Primary Use")
   {
    R_Date("OxA-1906", 5100, 80)
    {
     Outlier();
    };
    R_Date("OxA-25950", 5004, 31);
    R_Date("OxA-26052", 4983, 30);
    R_Date("OxA-25947", 4949, 30);
    R_Date("OxA-25948", 4937, 31);
    R_Date("OxA-25943", 4928, 30);
    R_Combine()
    {
     R_Date("OxA-22651", 4947, 30);
     R_Date("OxA-22650", 4927, 30);
    };
    R_Date("OxA-1910", 4940, 80)
    {
     Outlier();
    };
    R_Date("OxA-1905", 4930, 80)
    {
     Outlier();
    };
    R_Date("OxA-25940", 4914, 30);
    R_Date("UBA-15770", 4894, 28)
    {
     Outlier();
    };
    R_Date("OxA-25949", 4845, 29);
    R_Date("OxA-1912", 4810, 80)
    {
     Outlier();
    };
    R_Date("OxA-25942", 4799, 30);
    R_Date("OxA-25944", 4794, 30);
    R_Date("OxA-25941", 4775, 31);
    R_Date("UBA-15768", 4731, 31);
    R_Date("UBA-15769", 4728, 28);
    R_Date("OxA-1911", 4720, 70)
    {
     Outlier();
```

```
   };
   R_Date("OxA-26692", 4713, 30)
   {
    Outlier();
   };
   R_Date("OxA-26693", 4710, 28)
   {
    Outlier();
   };
  };
  Boundary("End Primary");
  Boundary("Start Later");
  Phase("Later Use")
  {
   R_Date("UBA-23506", 4600, 35)
   {
    Outlier();
   };
   R_Date("OxA-25945", 4579, 29);
   R_Date("OxA-25946", 4543, 40);
   R_Date("OxA-1909", 4550, 80)
   {
    Outlier();
   };
   R_Date("OxA-1907", 4520, 80)
   {
    Outlier();
   };
   R_Date("UBA-15771", 4508, 32);
   R_Date("OxA-1908", 4440, 80)
   {
    Outlier();
   };
   R_Date("OxA-1913", 4390, 90)
   {
    Outlier();
   };
  };
  Boundary("End Later");
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 112.9 Aoverall 114.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Poulnabrone Model 4																	
Boundary Start Primary							-3785	-3726	68.2	-3822	-3710	95.4					98.9
Phase Primary Use																	
R_Date OxA-1906	-3972	-3797	68.2	-4053	-3696	95.4	-3971	-3797	68.2	-4054	-3697	95.4				10	99.4
R_Date OxA-25950	-3895	-3712	68.2	-3941	-3702	95.4	-3752	-3706	68.2	-3796	-3695	95.4		100.5			99.8
R_Date OxA-26052	-3783	-3711	68.2	-3927	-3666	95.5	-3752	-3704	68.2	-3785	-3664	95.4		105.7			99.8
R_Date OxA-25947	-3766	-3672	68.2	-3786	-3656	95.4	-3742	-3664	68.2	-3766	-3656	95.4		102.7			99.9
R_Date OxA-25948	-3761	-3659	68.2	-3778	-3652	95.4	-3717	-3657	68.2	-3764	-3652	95.4		106			99.9
R_Date OxA-25943	-3712	-3655	68.2	-3769	-3651	95.4	-3710	-3657	68.2	-3757	-3650	95.4		106.1			99.9
R_Combine(4937,22)	-3748	-3661	68.2	-3766	-3656	95.4	-3713	-3662	68.2	-3757	-3656	95.4		104.7			99.9
R_Date OxA-1910	-3888	-3644	68.2	-3951	-3538	95.4	-3888	-3644	68.2	-3952	-3538	95.4				57.8	99.4
R_Date OxA-1905	-3795	-3641	68.2	-3947	-3536	95.4	-3796	-3641	68.2	-3946	-3536	95.4				61.2	99.3
R_Date OxA-25940	-3703	-3656	68.2	-3764	-3644	95.4	-3702	-3657	68.2	-3753	-3643	95.4		104.1			99.9
R_Date UBA-15770	-3695	-3650	68.2	-3710	-3639	95.4	-3694	-3651	68.2	-3711	-3639	95.4				98.8	99.7
R_Date OxA-25949	-3659	-3541	68.2	-3696	-3535	95.4	-3662	-3632	68.2	-3699	-3537	95.4		105.3			99.9
R_Date OxA-1912	-3694	-3386	68.3	-3763	-3373	95.4	-3693	-3388	68.3	-3762	-3374	95.4				61.6	99.2
R_Date OxA-25942	-3640	-3534	68.2	-3649	-3522	95.4	-3645	-3545	68.2	-3651	-3531	95.4		91.3			99.7
R_Date OxA-25944	-3639	-3533	68.2	-3646	-3522	95.4	-3643	-3548	68.2	-3648	-3531	95.4		91.6			99.7
R_Date OxA-25941	-3635	-3527	68.2	-3642	-3386	95.4	-3639	-3561	68.2	-3641	-3531	95.4		98.9			99.7
R_Date UBA-15768	-3630	-3383	68.2	-3635	-3377	95.4	-3631	-3585	68.2	-3636	-3517	95.4		114.6			99.9
R_Date UBA-15769	-3629	-3383	68.2	-3635	-3377	95.4	-3630	-3587	68.2	-3636	-3516	95.4		113.1			99.8
R_Date OxA-1911	-3631	-3378	68.2	-3638	-3370	95.4	-3631	-3378	68.2	-3638	-3370	95.4				36.1	99.4
R_Date OxA-26692	-3626	-3380	68.2	-3631	-3374	95.4	-3625	-3380	68.3	-3632	-3374	95.4				31.6	99.8
R_Date OxA-26693	-3623	-3380	68.2	-3631	-3374	95.4	-3623	-3380	68.1	-3631	-3373	95.4				28.6	99.6

Boundary End Primary							-3583	-3510	68.2	-3621	-3476	95.4					99
Boundary Start Later							-3434	-3201	68.2	-3517	-3144	95.4					99.1
Phase Later Use																	
R_Date UBA-23506	-3496	-3346	68.2	-3513	-3124	95.5	-3496	-3346	68.2	-3513	-3123	95.4				28.9	99.5
R_Date OxA-25945	-3486	-3143	68.3	-3497	-3118	95.4	-3370	-3196	68.2	-3376	-3121	95.4		106.5			99.8
R_Date OxA-25946	-3364	-3117	68.3	-3370	-3098	95.4	-3367	-3141	68.2	-3370	-3122	95.4		113.8			99.5
R_Date OxA-1909	-3483	-3101	68.1	-3520	-3012	95.4	-3483	-3102	68.1	-3520	-3012	95.4				29	99.2
R_Date OxA-1907	-3358	-3099	68.2	-3498	-2930	95.4	-3358	-3100	68.2	-3498	-2930	95.4				28.6	99.5
R_Date UBA-15771	-3340	-3110	68.2	-3352	-3097	95.4	-3361	-3183	68.2	-3364	-3121	95.4		94.9			99.4
R_Date OxA-1908	-3329	-2940	68.2	-3347	-2918	95.4	-3329	-2941	68.2	-3347	-2917	95.4				21.9	99.2
R_Date OxA-1913	-3311	-2904	68.2	-3346	-2888	95.4	-3316	-2903	68.2	-3346	-2887	95.4				16.6	99.2
Boundary End Later							-3355	-3111	68.2	-3361	-2989	95.4					97

Table C.22 Bayesian model for the start of the use at Poulnabrone – Model 4 after (Schulting, 2014)

C.4.3. Bayesian model for the start of the use at Poulnabrone – Model 5 after (Schulting 2014)

```
Plot()
 {
  Sequence("Poulnabrone Model 5")
  {
   Boundary("Start");
   Phase("Neolihtic Use")
   {
    R_Date("OxA-1906", 5100, 80);
    R_Date("OxA-1910", 4940, 80);
    R_Date("OxA-1905", 4930, 80);
    R_Date("OxA-1912", 4810, 80);
    R_Date("OxA-1911", 4720, 70);
    R_Date("OxA-1909", 4550, 80);
    R_Date("OxA-1907", 4520, 80);
    R_Date("OxA-1908", 4440, 80);
    R_Date("OxA-1913", 4390, 90);
    R_Date("OxA-25950", 5004, 31);
    R_Date("OxA-26052", 4983, 30);
    R_Date("OxA-25947", 4949, 30);
    R_Date("OxA-25948", 4937, 31);
    R_Date("OxA-25943", 4928, 30);
    R_Combine()
    {
     R_Date("OxA-22651", 4947, 30);
     R_Date("OxA-22650", 4927, 30);
    };
    R_Date("OxA-25940", 4914, 30);
    R_Date("UBA-15770", 4894, 28);
    R_Date("OxA-25949", 4845, 29);
    R_Date("OxA-25942", 4799, 30);
    R_Date("OxA-25944", 4794, 30);
    R_Date("OxA-25941", 4775, 31);
    R_Date("UBA-15768", 4731, 31);
    R_Date("UBA-15769", 4728, 28);
    R_Date("OxA-26692", 4713, 30);
    R_Date("OxA-26693", 4710, 28);
    R_Date("UBA-23506", 4600, 35);
    R_Date("OxA-25945", 4579, 29);
    R_Date("OxA-25946", 4543, 40);
    R_Date("UBA-15771", 4508, 32);
   };
   Boundary("End");
  };
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 90.9 Aoverall 91.2				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Sequence Poulnabrone Model 5																	
Boundary Start							-3819	-3754	68.2	-3877	-3726	95.4					99.1
Phase Neolihtic Use																	
R_Date OxA-1906	-3972	-3797	68.2	-4053	-3696	95.4	-3794	-3707	68.2	-3836	-3656	95.4		53.7			99.8
R_Date OxA-1910	-3888	-3644	68.2	-3951	-3538	95.4	-3758	-3654	68.2	-3807	-3533	95.4		116			99.9
R_Date OxA-1905	-3795	-3641	68.2	-3947	-3536	95.4	-3756	-3650	68.2	-3805	-3529	95.4		115.4			99.8
R_Date OxA-1912	-3694	-3386	68.3	-3763	-3373	95.4	-3694	-3387	68.3	-3757	-3373	95.4		101.2			99.8
R_Date OxA-1911	-3631	-3378	68.2	-3638	-3370	95.4	-3631	-3378	68.3	-3638	-3370	95.4		100.4			99.8
R_Date OxA-1909	-3483	-3101	68.1	-3520	-3012	95.4	-3498	-3268	68.2	-3622	-3181	95.4		95.9			99.8
R_Date OxA-1907	-3358	-3099	68.2	-3498	-2930	95.4	-3490	-3263	68.2	-3516	-3176	95.4		96			99.7
R_Date OxA-1908	-3329	-2940	68.2	-3347	-2918	95.4	-3355	-3269	68.2	-3493	-3165	95.4		91.2			99.6
R_Date OxA-1913	-3311	-2904	68.2	-3346	-2888	95.4	-3351	-3260	68.2	-3491	-3166	95.4		67.1			99.7
R_Date OxA-25950	-3895	-3712	68.2	-3941	-3702	95.4	-3778	-3711	68.2	-3804	-3701	95.4		109			99.9
R_Date OxA-26052	-3783	-3711	68.2	-3927	-3666	95.5	-3766	-3709	68.2	-3797	-3671	95.4		110.2			99.9
R_Date OxA-25947	-3766	-3672	68.2	-3786	-3656	95.4	-3760	-3670	68.2	-3777	-3657	95.4		102.4			99.9
R_Date OxA-25948	-3761	-3659	68.2	-3778	-3652	95.4	-3757	-3659	68.2	-3772	-3652	95.4		102.2			99.9
R_Date OxA-25943	-3712	-3655	68.2	-3769	-3651	95.4	-3712	-3656	68.2	-3765	-3651	95.4		101.6			99.9
R_Combine(4937,22)	-3748	-3661	68.2	-3766	-3656	95.4	-3714	-3660	68.2	-3764	-3656	95.4		100.5			99.9
R_Date OxA-25940	-3703	-3656	68.2	-3764	-3644	95.4	-3703	-3656	68.2	-3761	-3644	95.4		100.8			99.9
R_Date UBA-15770	-3695	-3650	68.2	-3710	-3639	95.4	-3695	-3650	68.2	-3710	-3640	95.4		99.9			99.9
R_Date OxA-25949	-3659	-3541	68.2	-3696	-3535	95.4	-3660	-3541	68.2	-3696	-3535	95.4		97.6			99.8
R_Date OxA-25942	-3640	-3534	68.2	-3649	-3522	95.4	-3640	-3534	68.2	-3649	-3522	95.4		98.8			99.9
R_Date OxA-25944	-3639	-3533	68.2	-3646	-3522	95.4	-3639	-3533	68.2	-3646	-3522	95.4		98.9			99.9
R_Date OxA-25941	-3635	-3527	68.2	-3642	-3386	95.4	-3635	-3527	68.2	-3644	-3386	95.4		99.5			99.9

R_Date UBA-15768	-3630	-3383	68.2	-3635	-3377	95.4	-3630	-3384	68.1	-3635	-3377	95.4		99.4			99.9
R_Date UBA-15769	-3629	-3383	68.2	-3635	-3377	95.4	-3628	-3384	68.2	-3635	-3377	95.4		99.2			99.9
R_Date OxA-26692	-3626	-3380	68.2	-3631	-3374	95.4	-3625	-3380	68.2	-3632	-3374	95.3		99.4			99.8
R_Date OxA-26693	-3623	-3380	68.2	-3631	-3374	95.4	-3623	-3380	68.2	-3631	-3373	95.4		99.4			99.9
R_Date UBA-23506	-3496	-3346	68.2	-3513	-3124	95.5	-3495	-3347	68.2	-3513	-3199	95.4		108.6			99.8
R_Date OxA-25945	-3486	-3143	68.3	-3497	-3118	95.4	-3482	-3340	68.2	-3499	-3188	95.4		120.9			99.5
R_Date OxA-25946	-3364	-3117	68.3	-3370	-3098	95.4	-3367	-3289	68.2	-3492	-3181	95.4		98.5			99.7
R_Date UBA-15771	-3340	-3110	68.2	-3352	-3097	95.4	-3352	-3284	68.2	-3362	-3192	95.4		95.9			99.8
Boundary End							-3320	-3212	68.2	-3335	-3110	95.4					96.6

Table C.23 Bayesian model for the start of the use at Poulnabrone – Model 5 after (Schulting, 2014)

C.4.4. Model of 'Event' order for the palynological 'events' and the start and end of the Early Neolithic in the south of Ireland

```
Plot()
 {
  Prior("Arderrawinny_Begin_Plantago","Arderrawinny_Begin_Plantago.prior");

Prior("Arderrawinny_Pre_ED_Peak_Plantago","Arderrawinny_Pre_ED_Peak_Plantago
.prior");
  Prior("Arderrawinny_Elm_Decline","Arderrawinny_Elm_Decline.prior");

Prior("Arderrawinny_Post_ED_Peak_Plantago","Arderrawinny_Post_ED_Peak_Planta
go.prior");
  Prior("Arderrawinny_End_Plantago","Arderrawinny_End_Plantago.prior");
  Prior("Knockadoon_South_Elm_Decline","Knockadoon_South_Elm_Decline.prior");
  Prior("Lough_Cullin_Elm_Decline","Lough_Cullin_Elm_Decline.prior");
  Prior("Lough_Cullin_Start_Landnam","Lough_Cullin_Start_Landnam.prior");
  Prior("Lough_Cullin_Begin_Plantago","Lough_Cullin_Begin_Plantago.prior");
  Prior("Lough_Cullin_1st_Cultivation","Lough_Cullin_1st_Cultivation.prior");

Prior("Lough_Cullin_Second_Cultivation","Lough_Cullin_Second_Cultivation.prior");

Prior("Lough_Cullin_Peak_Plantago_Landnam","Lough_Cullin_Peak_Plantago_Landn
am.prior");

Prior("Lough_Cullin_Elm_Recovery_End_Plantago","Lough_Cullin_Elm_Recovery_E
nd_Plantago.prior");

  Prior("Lough_Cullin_End_Landnam","Lough_Cullin_End_Landnam.prior");
  Prior("Poulnabrone_Model_3","Poulnabrone_Model_3.prior");
  Prior("Poulnabrone_Model_4","Poulnabrone_Model_4.prior");
  Prior("Poulnabrone_Model_5","Poulnabrone_Model_5.prior");
  Prior("Start_House_Occupation","Start_House_Occupation.prior");
  Prior("Start_Ephemeral_Occupation","Start_Ephemeral_Occupation.prior");
  Prior("Start_Cereal_Cultivation","Start_Cereal_Cultivation.prior");
  Prior("Start_Burials","Start_Burials.prior");
  Prior("End_House_Occupation","End_House_Occupation.prior");
  Prior("End_Ephemeral_Occupation","End_Ephemeral_Occupation.prior");
  Prior("End_Burials","End_Burials.prior");
  Prior("End_Cereal_Cultivation","End_Cereal_Cultivation.prior");
  Prior("Start_Model_1","Start_Model_1.prior");
  Prior("Start_Model_3","Start_Model_3.prior");
  Prior("End_Model_1","End_Model_1.prior");
  Prior("End_Model_3","End_Model_3.prior");
  Prior("Ferriters_cove_Cattle_Bone","Ferriters_cove_Cattle_Bone.prior");

Prior("Kilgreany_Cave_Cattle_Bone_OxA_4269_","Kilgreany_Cave_Cattle_Bone_Ox
A_4269_.prior");
  Order()
  {
```

```
  Date("=Arderrawinny_Begin_Plantago");
  Date("=Arderrawinny_Pre_ED_Peak_Plantago");
  Date("=Arderrawinny_Elm_Decline");
  Date("=Arderrawinny_Post_ED_Peak_Plantago");
  Date("=Arderrawinny_End_Plantago");
  Date("=Knockadoon_South_Elm_Decline");
  Date("=Lough_Cullin_Elm_Decline");
  Date("=Lough_Cullin_Start_Landnam");
  Date("=Lough_Cullin_Begin_Plantago");
  Date("=Lough_Cullin_1st_Cultivation");
  Date("=Lough_Cullin_Second_Cultivation");
  Date("=Lough_Cullin_Peak_Plantago_Landnam");
  Date("=Lough_Cullin_Elm_Recovery_End_Plantago");
  Date("=Lough_Cullin_End_Landnam")
  Date("=Poulnabrone_Model_3");
  Date("=Poulnabrone_Model_4");
  Date("=Poulnabrone_Model_5");
  Date("=Start_House_Occupation");
  Date("=Start_Ephemeral_Occupation");
  Date("=Start_Cereal_Cultivation");
  Date("=Start_Burials");
  Date("=End_House_Occupation");
  Date("=End_Ephemeral_Occupation");
  Date("=End_Burials");
  Date("=End_Cereal_Cultivation");
  Date("=Start_Model_1");
  Date("=Start_Model_3");
  Date("=End_Model_1");
  Date("=End_Model_3");
  Date("=Kilgreany_Cave_Cattle_Bone_OxA_4269_");
  Date("=Ferriters_cove_Cattle_Bone");
 };
};
```

C.4.5. OxCal *P_Sequence* model for Ballinphuill (Molloy *et al.* 2014)

```
Plot()
 {
  P_Sequence("Ballinphuill",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=782;
   };
   Date("Ballinphuill 2 Elm Decline")
   {
    z=676;
   };
   Date("Ballinphuill 2 Plantago Rise")
   {
    z=665;
   };
   R_Date("GrN-30541", 4450, 60)
   {
    z=665;
    Outlier();
   };
   R_Date("GrA-35929", 4655, 35)
   {
    z=631;
   };
   Date("Ballinphuill End Plantago Curve")
   {
    z=620;
   };
   R_Date("GrA-33490", 4320, 40)
   {
    z=582;
   };
   R_Date("GrA-35974", 4020, 35)
```

```
{
 z=547;
};
R_Date("GrA-35932", 3885, 35)
{
 z=517;
};
R_Date("GrA-35930", 3795, 35)
{
 z=491;
};
R_Date("GrA-35973", 4005, 35)
{
 z=451;
 Outlier();
};
R_Date("GrA-33487", 3140, 45)
{
 z=391;
};
R_Date("GrA-33486", 2840, 40)
{
 z=345;
};
R_Date("GrA-35944", 2245, 35)
{
 z=302;
};
R_Date("GrA-33499", 2145, 35)
{
 z=262;
};
R_Date("GrA-35971", 1940, 35)
{
 z=230;
```

```
 };
 R_Date("GrA-35970", 1675, 30)
 {
  z=205;
 };
 R_Date("GrA-35969 ", 1525, 35)
 {
  z=181;
 };
 R_Date("GrA-35008", 1310, 35)
 {
  z=167;
 };
 R_Date("GrA-35967", 935, 30)
 {
  z=122;
 };
 Boundary("t")
 {
  z=40;
 };
 Before()
 {
  C_Date(2000, 4);
 };
};
Difference("", "Ballinphuill 2 Plantago Rise", "Ballinphuill 2 Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 100.5 Aoverall 99.1				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Ballinphuill (1,0.04,U(-2,2))	-2	2	68.2	-2	2	95.4	-0.78313	-0.28313	68.2	-1.05913	-0.05113	95.4		100			99.6
b							-4998	-4514	68.2	-5351	-4268	95.4					97.5
Ballinphuill 2 Elm Decline							-3941	-3691	68.2	-4125	-3578	95.4					99.8
Ballinphuill 2 Plantago Rise							-3830	-3609	68.2	-3988	-3512	95.4					99.8
GrN-30541 (4450,60)	-3330	-3020	68.2	-3341	-2929	95.4	-3330	-3020	68.3	-3341	-2929	95.4				0.1	99.7
GrA-35929 (4655,35)	-3506	-3369	68.2	-3619	-3361	95.4	-3497	-3366	68.2	-3514	-3362	95.4		99.5			99.8
Ballinphuill End Plantago Curve							-3396	-3261	68.2	-3463	-3187	95.4					99.8
GrA-33490 (4320,40)	-3010	-2892	68.2	-3081	-2883	95.4	-3003	-2892	68.1	-3019	-2886	95.4		105.1			99.8
GrA-35974 (4020,35)	-2574	-2489	68.2	-2624	-2468	95.4	-2621	-2525	68.2	-2663	-2484	95.4		82			99.8
GrA-35932 (3885,35)	-2457	-2311	68.2	-2471	-2214	95.4	-2430	-2335	68.2	-2461	-2296	95.4		107.8			99.8
GrA-35930 (3795,35)	-2287	-2151	68.2	-2397	-2061	95.4	-2259	-2144	68.1	-2293	-2135	95.4		104.6			99.9
GrA-35973 (4005,35)	-2569	-2478	68.2	-2619	-2465	95.4	-2569	-2479	68.2	-2619	-2464	95.4					99.7
GrA-33487 (3140,45)	-1494	-1311	68.2	-1501	-1292	95.4	-1446	-1306	68.2	-1494	-1290	95.4		98.8			99.8
GrA-33486 (2840,40)	-1048	-931	68.2	-1121	-903	95.4	-1007	-917	68.2	-1072	-850	95.4		101.2			99.9
GrA-35944 (2245,35)	-382	-215	68.2	-395	-204	95.4	-392	-358	68.2	-403	-280	95.4		94.2			99.9
GrA-33499 (2145,35)	-349	-112	68.3	-356	-54	95.4	-191	-104	68.2	-207	-58	95.4		96.6			99.9
GrA-35971 (1940,35)	22	120	68.2	-37	130	95.4	53	127	68.2	3	169	95.4		95.7			99.9
GrA-35970 (1675,30)	340	405	68.2	258	425	95.4	338	396	68.2	259	420	95.4		100.3			99.9
GrA-35969 (1525,35)	434	590	68.3	427	605	95.4	535	595	68.2	461	620	95.4		109.2			99.9
GrA-35008 (1310,35)	663	764	68.2	654	770	95.4	660	711	68.2	653	766	95.4		103.8			99.9
GrA-35967 (935,30)	1039	1152	68.2	1026	1162	95.4	1035	1127	68.2	1027	1158	95.4		100.8			99.8
t							1672	1941	68.2	1530	2001	95.4					99.7
	...	1998.15	68.2	...	1993.25	95.4											
Ballinphuill 2 Plantago Rise,Ballinphuill 2 Elm Decline							29	130	68.2	1	217	95.4					99.9

Table C.24 OxCal P_Sequence model for Ballinphuill

C.4.6. OxCal *P_Sequence* model for Ballynagilly (Pilcher and Smith 1979)

```
Plot()
 {
  P_Sequence("Ballynagilly",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=404;
   };
   R_Date("UB-297", 9595, 125)
   {
    z=402;
   };
   R_Date("UB-260", 9595, 80)
   {
    z=382;
   };
   R_Date("UB-322D", 9535, 110)
   {
    z=378;
   };
   R_Date("UB-258", 8095, 80)
   {
    z=332;
   };
   R_Date("UB-257", 7275, 95)
   {
    z=312;
   };
   R_Date("UB-255", 5920, 60)
   {
    z=272;
   };
   R_Date("UB-254", 5575, 70)
   {
    z=263;
   };
   Date("Ballynagilly Elm Decline")
   {
    z=256;
   };
   R_Date("UB-253", 5145, 70)
   {
    z=255;
   };
   R_Date("UB-252", 4850, 70)
   {
    z=246;
   };
   Date("Ballynagilly Plantago Rise")
   {
    z=244;
   };
   R_Date("UB-251", 4540, 65)
```

```
 {
  z=238;
 };
 Date("End Plantago Curve")
 {
  z=237;
 };
 R_Date("UB-250", 4340, 65)
 {
  z=228;
 };
 R_Date("UB-249", 4025, 65)
 {
  z=216;
 };
 R_Date("UB-248", 3955, 55)
 {
  z=206;
 };
 R_Date("UB-247", 3620, 60)
 {
  z=196;
 };
 R_Date("UB-246", 3340, 65)
 {
  z=180;
 };
 R_Date("UB-245", 3135, 60)
 {
  z=166;
 };
 R_Date("UB-244", 2375, 80)
 {
  z=122;
 };
 R_Date("UB-242", 695, 80)
 {
  z=42;
 };
 Boundary("t")
 {
  z=0;
 };
};
Difference("", "Ballynagilly Plantago Rise", "Ballynagilly Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 103.7 Aoverall 103.5				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Ballynagilly	-2	2	68.2	-2	2	95.4	-0.74396	-0.34396	68.2	-0.92796	-0.14396	95.4		100			98.5
b							-9323	-9105	68.2	-9489	-8964	95.4					96.8
UB-297	-9182	-8815	68.2	-9276	-8639	95.4	-9266	-9095	68.2	-9345	-8939	95.4		91.8			99.1
UB-260	-9154	-8835	68.2	-9236	-8761	95.4	-8930	-8774	68.2	-9059	-8706	95.4		94.5			99.8
UB-322D	-9139	-8748	68.2	-9236	-8623	95.4	-8867	-8656	68.2	-8981	-8573	95.4		96.6			99.6
UB-258	-7284	-6838	68.2	-7331	-6771	95.4	-7180	-6833	68.2	-7303	-6772	95.4		101.5			99.6
UB-257	-6231	-6051	68.2	-6369	-5992	95.4	-6240	-6060	68.2	-6372	-6008	95.4		99.6			99.7
UB-255	-4878	-4718	68.2	-4963	-4619	95.4	-4841	-4716	68.2	-4940	-4618	95.4		103.1			99.8
UB-254	-4463	-4347	68.2	-4553	-4266	95.4	-4456	-4351	68.2	-4543	-4271	95.4		103.3			99.8
Ballynagilly Elm Decline							-4092	-3842	68.2	-4260	-3800	95.4					99
UB-253	-4040	-3806	68.1	-4226	-3768	95.4	-4043	-3832	68.2	-4223	-3790	95.4		102.2			99.4
UB-252	-3708	-3528	68.2	-3790	-3381	95.4	-3704	-3531	68.2	-3780	-3386	95.5		104.6			99.6
Ballynagilly Plantago Rise							-3672	-3461	68.2	-3742	-3298	95.4					99.6
UB-251	-3364	-3106	68.3	-3499	-3025	95.3	-3370	-3176	68.2	-3497	-3096	95.4		103.1			99.3
End Plantago Curve							-3357	-3151	68.2	-3491	-3045	95.4					99.2
UB-250	-3081	-2894	68.2	-3328	-2872	95.4	-3022	-2901	68.2	-3112	-2873	95.4		109			99.8
UB-249	-2831	-2469	68.2	-2864	-2347	95.4	-2667	-2496	68.2	-2852	-2466	95.4		98.6			99.8
UB-248	-2568	-2348	68.2	-2619	-2287	95.4	-2487	-2310	68.2	-2567	-2284	95.4		92.2			99.8
UB-247	-2116	-1896	68.2	-2194	-1777	95.4	-2132	-1942	68.2	-2195	-1885	95.4		99.2			99.8
UB-246	-1691	-1531	68.2	-1866	-1456	95.4	-1736	-1569	68.2	-1771	-1506	95.4		104.9			99.8
UB-245	-1495	-1304	68.2	-1528	-1232	95.4	-1491	-1306	68.2	-1507	-1265	95.4		105.3			99.8
UB-244	-741	-380	68.2	-771	-233	95.4	-661	-371	68.2	-754	-237	95.4		106.5			99.8
UB-242	1251	1394	68.2	1170	1415	95.4	1258	1395	68.2	1191	1420	95.4		101.3			99.7

t							2058	2864	68.2	1721	3377	95.4					97.8
Ballynagilly Plantago Rise,Ballynagilly Elm Decline							301	613	68.2	175	811	95.4					99.5

Table C.25 OxCal P_Sequence model for Ballynagilly

C.4.7. OxCal *P_Sequence* model for Ballyscullion (Smith *et al.* 1971; Smith 1975)

```
Plot()
 {
  P_Sequence("Ballyscullion",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=418;
   };
   R_Date("UB-120", 6950, 85)
   {
    z=417;
   };
   R_Date("UB-119", 6430, 85)
   {
    z=399;
   };
   R_Date("UB-118", 6000, 85)
   {
    z=376;
   };
   R_Date("UB-296", 5815, 90)
   {
    z=355;
   };
   R_Date("UB-116", 5530, 60)
   {
    z=342;
   };
   R_Date("UB-295", 5250, 85)
   {
    z=332;
   };
   R_Date("UB-115", 5130, 60)
   {
    z=312;
   };
   R_Date("UB-114", 4990, 55)
   {
    z=306;
   };
   Date("Ballyscullion Elm Decline")
   {
    z=305;
   };
   Date("Ballyscullion Plantago Rise")
   {
    z=303;
   };
```

```
 R_Date("UB-113", 4840, 60)
 {
  z=299;
 };
 R_Date("UB-294", 4830, 60)
 {
  z=292;
 };
 R_Date("UB-112", 4570, 55)
 {
  z=285;
 };
 R_Date("UB-111", 4200, 85)
 {
  z=252;
 };
 R_Date("UB-110", 3920, 85)
 {
  z=237;
 };
 R_Date("UB-109", 3835, 80)
 {
  z=206;
 };
 Boundary("t")
 {
  z=205;
 };
};
Difference("", "Ballyscullion Plantago Rise", "Ballyscullion Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 76.7 Aoverall 74.9				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Ballyscullion	-2	2	68.2	-2	2	95.4	-0.27311	1.16289	68.2	-0.42111	1.97489	95.4		100			97.6
Boundary b							-5817	-5688	68.2	-5897	-5650	95.4					97.8
R_Date UB-120	-5966	-5739	68.2	-5999	-5675	95.4	-5801	-5669	68.2	-5875	-5635	95.4		82.1			99.1
R_Date UB-119	-5475	-5330	68.2	-5539	-5225	95.4	-5461	-5365	68.2	-5499	-5314	95.4		117.6			99.5
R_Date UB-118	-5000	-4788	68.2	-5207	-4706	95.5	-5041	-4946	68.2	-5080	-4861	95.4		93			99.6
R_Date UB-296	-4771	-4552	68.2	-4896	-4460	95.4	-4667	-4582	68.2	-4715	-4529	95.4		120			99.6
R_Date UB-116	-4448	-4337	68.2	-4493	-4261	95.4	-4429	-4355	68.2	-4458	-4327	95.4		111.7			99.7
R_Date UB-295	-4228	-3976	68.2	-4326	-3819	95.5	-4257	-4186	68.2	-4297	-4114	95.4		90.3			99.8
R_Date UB-115	-3989	-3804	68.2	-4048	-3777	95.4	-3907	-3832	68.2	-3956	-3801	95.4		96.4			99.6
R_Date UB-114	-3924	-3701	68.2	-3943	-3658	95.4	-3801	-3743	68.2	-3840	-3697	95.4		121.9			99.7
Ballyscullion Elm Decline							-3786	-3726	68.2	-3822	-3678	95.4					99.7
Ballinscullion Plantago Rise							-3752	-3696	68.2	-3788	-3645	95.4					99.8
R_Date UB-113	-3696	-3532	68.2	-3766	-3384	95.4	-3683	-3633	68.2	-3711	-3573	95.4		119.7			99.8
R_Date UB-294	-3694	-3526	68.2	-3760	-3381	95.4	-3574	-3522	68.2	-3640	-3415	95.4		104.8			99.9
R_Date UB-112	-3493	-3116	68.2	-3508	-3095	95.4	-3481	-3355	68.2	-3499	-3323	95.4		68.6			99.3
R_Date UB-111	-2898	-2666	68.2	-3011	-2499	95.3	-2894	-2786	68.2	-2928	-2692	95.4		113.4			99.6
R_Date UB-110	-2565	-2287	68.2	-2831	-2141	95.4	-2631	-2522	68.2	-2696	-2436	95.4		58.1			99.6
R_Date UB-109	-2455	-2201	68.2	-2489	-2037	95.4	-2171	-1979	68.1	-2276	-1938	95.4		45.2			98.1
Boundary t							-2157	-1963	68.3	-2259	-1912	95.4					97.7
Ballyscullion Plantago Rise,Ballyscullion Elm Decline							15	45	68.2	-2	65	95.4					99.3

Table C.26 OxCal P_Sequence model for Ballyscullion

C.4.8. OxCal *P_Sequence* model for Beaghmore (Pilcher 1969)

```
Plot()
 {
  P_Sequence("Beaghmore",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=390;
   };
   R_Date("UB-96", 7000, 90)
   {
    z=360;
   };
   R_Date("UB-95", 6225, 50)
   {
    z=336;
   };
   R_Date("UB-94", 6050, 60)
   {
    z=310;
   };
   R_Date("UB-93", 5295, 75)
   {
    z=296;
   };
   Date("Beaghmore Elm Decline")
   {
    z=288;
   };
   R_Date("UB-99", 5285, 70)
   {
    z=287;
   };
   R_Date("UB-98", 4995, 60)
   {
    z=283;
   };
   R_Date("UB-97", 4640, 55)
   {
    z=279;
   };
   R_Date("UB-92", 4525, 55)
   {
    z=272;
   };
   R_Date("UB-91", 3880, 65)
   {
    z=244;
```

```
 };
 R_Date("UB-90", 3350, 65)
 {
  z=216;
 };
 R_Date("UB-89", 2800, 60)
 {
  z=192;
 };
 R_Date("UB-87", 2090, 70)
 {
  z=128;
 };
 R_Date("UB-86", 1590, 75)
 {
  z=96;
 };
 R_Date("UB-84", 670, 60)
 {
  z=40;
 };
 Boundary("t")
 {
  z=0;
 };
};
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 99.7 Aoverall 99.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Beaghmore	-2	2	68.2	-2	2	95.4	-1.02694	-0.65895	68.2	-1.26694	-0.51495	95.4		100			96.7
Boundary b							-6755	-6093	68.2	-7272	-5882	95.4					99.2
R_Date UB-96	-5984	-5801	68.2	-6033	-5719	95.4	-5961	-5751	68.2	-6022	-5711	95.4		98.6			99.9
R_Date UB-95	-5295	-5077	68.2	-5310	-5051	95.4	-5305	-5148	68.2	-5314	-5075	95.4		102.4			99.9
R_Date UB-94	-5031	-4848	68.2	-5207	-4793	95.4	-4971	-4809	68.2	-5051	-4746	95.4		97.3			99.9
R_Date UB-93	-4234	-4042	68.2	-4323	-3974	95.4	-4309	-4104	68.2	-4330	-4042	95.4		98.9			99.8
Baeghmore Elm Decline							-4124	-3984	68.2	-4229	-3961	95.4					99.7
R_Date UB-99	-4231	-4002	68.3	-4318	-3971	95.4	-4102	-3975	68.2	-4218	-3957	95.4		96.8			99.8
R_Date UB-98	-3931	-3703	68.2	-3944	-3661	95.4	-3936	-3703	68.2	-3947	-3661	95.4		98.8			100
R_Date UB-97	-3515	-3359	68.2	-3631	-3130	95.4	-3518	-3360	68.2	-3631	-3340	95.4		102.5			99.9
R_Date UB-92	-3355	-3107	68.2	-3485	-3027	95.4	-3363	-3144	68.1	-3485	-3039	95.4		101.9			99.9
R_Date UB-91	-2467	-2287	68.2	-2562	-2146	95.4	-2465	-2292	68.2	-2564	-2151	95.5		102.3			99.9
R_Date UB-90	-1736	-1534	68.2	-1872	-1465	95.3	-1732	-1536	68.2	-1868	-1465	95.3		102			99.9
R_Date UB-89	-1021	-850	68.2	-1116	-824	95.4	-1109	-904	68.2	-1191	-837	95.4		91.8			99.9
R_Date UB-87	-202	-2	68.2	-357	55	95.4	-176	-2	68.2	-346	65	95.4		104.8			99.9
R_Date UB-86	395	550	68.2	259	621	95.4	394	541	68.2	260	608	95.4		102			99.9
R_Date UB-84	1275	1390	68.2	1251	1411	95.4	1272	1389	68.2	1248	1408	95.4		99.7			99.9
Boundary t							1767	1999	68.2	1549	2005	95.4					99.9

Table C.27 OxCal P_Sequence model for Beaghmore

C.4.9. OxCal *P_Sequence* model for Caheraphuca Lough (Molloy and O'Connell 2011)

```
Plot()
 {
  P_Sequence("Caheraphuca Lough",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=604;
   };
   Date("Caheraphuca Lough Elm Decline")
   {
    z=516;
   };
   Date("Caheraphuca Lough Begin Plantago Curve")
   {
    z=512;
   };
   R_Date("UBA-10625", 4695, 21)
   {
    z=501;
   };
   Date("Caheraphuca End Plantago")
   {
    z=496;
   };
   R_Date("UBA-11718", 4208, 26)
   {
    z=469;
   };
   R_Date("UBA-11717", 3889, 25)
   {
    z=449;
   };
   R_Date("UBA-10624", 3619, 19)
   {
    z=428;
   };
   R_Date("UBA-11716", 2942, 22)
   {
    z=373;
   };
   R_Date("UBA-11710", 2115, 23)
   {
    z=269;
   };
   Boundary("t")
   {
    z=268;
```

```
   };
  };
  Difference("", "Caheraphuca Lough Begin Plantago Curve", "Caheraphuca Lough Elm Decline");
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 102 Aoverall 102				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Caheraphuca Lough (1,0.04,U(-2,2))	-2	2	68.2	-2	2	95.4	-1.04634	-0.41034	68.2	-1.33434	-0.23434	95.4		100			99.3
b							-5341	-4424	68.2	-6051	-3964	95.4					98.1
Caheraphuca Lough Elm Decline							-3736	-3468	68.2	-3995	-3397	95.4					99.8
Caheraphuca Lough Begin Plantago Curve							-3657	-3434	68.2	-3881	-3384	95.4					99.8
UBA-10625 (4695,21)	-3519	-3378	68.2	-3624	-3374	95.4	-3511	-3377	68.2	-3618	-3372	95.4		104			99.9
Caheraphuca End Plantago							-3437	-3260	68.2	-3522	-3080	95.4					99.7
UBA-11718 (4208,26)	-2888	-2761	68.2	-2898	-2695	95.4	-2887	-2760	68.2	-2897	-2695	95.4		98			99.9
UBA-11717 (3889,25)	-2456	-2346	68.2	-2465	-2297	95.4	-2453	-2350	68.2	-2464	-2300	95.4		101.3			99.9
UBA-10624 (3619,19)	-2019	-1948	68.2	-2032	-1922	95.4	-2021	-1952	68.2	-2033	-1926	95.4		100.5			99.9
UBA-11716 (2942,22)	-1207	-1118	68.2	-1217	-1056	95.4	-1211	-1125	68.2	-1226	-1060	95.4		102.8			99.9
UBA-11710 (2115,23)	-183	-105	68.2	-200	-55	95.4	-175	-95	68.2	-195	-54	95.4		98.8			98
t							-172	-59	68.2	-200	-16	95.4					98.1
Caheraphuca Lough Begin Plantago Curve,Caheraphuca Lough Elm Decline							-2	66	68.2	-2	216	95.4					98.6

Table C.28 OxCal P_Sequence model for Caheraphuca Lough

C.4.10. OxCal *P_Sequence* model for Connemara National Park (FRK II) (O'Connell and Molloy 1988)

```
Plot()
 {
  P_Sequence("Connemara National Park (FRKII)",1,0.4,U(-2,2))
  {
   Boundary(b);
   R_Date("",9120,60)
   {
    z=349;
   };
   R_Date("",8610,80)
   {
    Outlier();
    z=335;
   };
   R_Combine("/")
   {
    R_Date("",8680,40);
    R_Date("",8630,45);
    z=311;
   };
   R_Date("",6915,40)
   {
    z=248;
   };
   R_Date("",5985,35)
   {
    z=212;
   };
   R_Date("",5355,30)
   {
    z=180;
   };
   Date("Elm Decline")
   {
    z=152;
   };
   R_Date("",4585,40)
   {
    z=148;
   };
   R_Date("",4005,25)
   {
    z=132;
   };
   R_Date("",3250,25)
   {
    z=92;
```

```
  };
  R_Date("",1385,20)
  {
   z=36;
  };
  Boundary(t);
 };
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 90.5 Aoverall 89.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Connemara National Park (FRKII)	-2	2	68.2	-2	2	95.4	-0.7533	-0.2493	68.2	-1.0173	0.022698	95.4		100			97.1
Boundary b							-8456	-8281	68.2	-8544	-8256	95.4					99.3
R_Date(9120,60)	-8428	-8273	68.2	-8535	-8244	95.4	-8456	-8281	68.2	-8544	-8256	95.4		87			99.3
R_Date(8610,80)	-7727	-7575	68.2	-7937	-7520	95.5	-7727	-7574	68.2	-7934	-7520	95.4				53.1	98.7
R_Combine /	-7677	-7599	68.2	-7729	-7595	95.4	-7665	-7597	68.2	-7722	-7592	95.4		105.9			99.6
R_Date(6915,40)	-5837	-5743	68.2	-5887	-5724	95.4	-5838	-5747	68.2	-5886	-5726	95.4		99.7			99.5
R_Date(5985,35)	-4932	-4810	68.2	-4981	-4787	95.4	-4933	-4836	68.2	-4976	-4789	95.4		100.9			99.7
R_Date(5355,30)	-4314	-4076	68.3	-4324	-4055	95.4	-4257	-4071	68.3	-4319	-4052	95.4		97.6			99.6
Elm Decline							-3462	-3195	68.2	-3626	-3136	95.4					98.3
R_Date(4585,40)	-3495	-3134	68.2	-3502	-3105	95.5	-3373	-3121	68.2	-3496	-3100	95.4		81.9			98.7
R_Date(4005,25)	-2567	-2486	68.2	-2575	-2472	95.4	-2571	-2489	68.2	-2576	-2474	95.4		99.8			99.5
R_Date(3250,25)	-1603	-1464	68.1	-1611	-1453	95.4	-1597	-1459	68.3	-1609	-1449	95.4		99.7			99.8
R_Date(1385,20)	644	661	68.2	619	669	95.4	643	661	68.2	618	669	95.4		96.6			99.8
Boundary t							643	661	68.2	618	669	95.4					99.8

Table C.29 OxCal P_Sequence model for Connemara National Park (FRK II)

C4.11. OxCal *P_Sequence* model for Cooney Lough (Ghilardi 2012)

```
Plot()
 {
  P_Sequence("Cooney Lough",1,0.1,U(-2,2))
  {
   Boundary();
   R_Date("UBA-17009",7792,36)
   {
    z=486;
   };
   R_Date("UBA-15790",7077,38)
   {
    z=476;
   };
   R_Date("UBA-15789",6481,32)
   {
    z=464;
   };
   R_Date("UBA-15788",5502,28)
   {
    z=444;
   };
   Date("Cooney Lough Elm Decline")
   {
    z=432;
   };
   R_Date("UBA-17008/Cooney Lough Plantago Rise",4928,32)
   {
    z=428;
   };
   R_Date("UBA-15787/Cooney Lough End Plantago",4653,30)
   {
    z=420;
   };
   R_Date("UBA-17010",3917,32)
```

```
  {
   z=394;
  };
  R_Date("UBA-15786",3379,26)
  {
   z=372;
  };
  R_Date("UBA-15785",3001,29)
  {
   z=350;
  };
  R_Date("UBA-15784",2846,24)
  {
   z=326;
  };
  R_Date("UBA-17011",2609,34)
  {
   z=302;
  };
  Boundary();
 };
 Difference("", "UBA-17008/Cooney Lough Plantago Rise", "Cooney Lough Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 96.9 Aoverall 96.7				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Cooney Lough	-2	2	68.2	-2	2	95.4	- 1.07543	- 0.70343	68.2	- 1.21143	- 0.55943	95.4		100			98.2
							-6654	-6535	68.2	-6681	-6504	95.4					99.1
UBA-17009	-6654	-6593	68.2	-6688	-6510	95.4	-6654	-6535	68.2	-6681	-6504	95.4		92.6			99.1
UBA-15790	-6006	-5914	68.2	-6025	-5885	95.4	-6006	-5915	68.2	-6026	-5886	95.4		99.9			99.2
UBA-15789	-5484	-5382	68.2	-5492	-5369	95.4	-5484	-5382	68.2	-5507	-5369	95.4		98.9			98.6
UBA-15788	-4364	-4332	68.2	-4446	-4269	95.4	-4364	-4332	68.2	-4446	-4269	95.4		98.8			99.5
Cooney Lough Elm Decline							-3930	-3661	68.2	-4221	-3653	95.4					96.7
UBA-17008/Cooney Lough Plantago Rise	-3713	-3655	68.2	-3771	-3650	95.4	-3714	-3653	68.2	-3770	-3649	95.4		101			99
UBA-15787/Cooney Lough End Plantago	-3500	-3369	68.2	-3517	-3364	95.4	-3502	-3371	68.2	-3519	-3364	95.4		99.5			98.8
UBA-17010	-2470	-2348	68.2	-2479	-2296	95.4	-2470	-2349	68.2	-2481	-2296	95.4		100. 2			99
UBA-15786	-1729	-1636	68.2	-1743	-1620	95.4	-1730	-1640	68.2	-1744	-1621	95.4		98.8			99.2
UBA-15785	-1283	-1134	68.2	-1377	-1127	95.4	-1368	-1207	68.2	-1382	-1131	95.4		101. 2			98.8
UBA-15784	-1044	-944	68.2	-1107	-925	95.4	-1047	-975	68.2	-1086	-926	95.4		102. 4			98.6
UBA-17011	-812	-785	68.2	-838	-674	95.4	-812	-783	68.2	-838	-591	95.4		95.5			97.9
							-812	-783	68.2	-838	-591	95.4					97.9
UBA-17008/Cooney Lough Plantago Rise,Cooney Lough Elm Decline							-2	218	68.2	-2	520	95.4					99

Table C.30 OxCal P_Sequence model for Cooney Lough

C4.12. OxCal *P_Sequence* model for Derragh Bog (Selby *et al.* 2005; Brown *et al.* 2005)

```
Plot()
 {
  P_Sequence("Derragh Bog",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=712;
   };
   R_Date("Beta-18414", 5350, 80)
   {
    z=682;
   };
   R_Date("Beta-18415", 4800, 60)
   {
    z=606;
   };
   Date("Derragh Bog Elm Decline")
   {
    z=600;
   };
   Date("Derragh Bog Plantago Rise")
   {
    z=592;
    color="Green";
   };
   R_Date("Beta-18416", 4750, 70)
   {
    z=589;
   };
   Date("End Plantago Curve")
   {
    z=578;
```

```
};
R_Date("Beta-18417", 4410, 60)
{
 z=551;
};
R_Date("Beta-18418", 4250, 70)
{
 z=539;
};
R_Date("Beta-18419", 3540, 70)
{
 z=457;
};
R_Date("Beta-18420", 2880, 70)
{
 z=391;
};
R_Date("Beta-18421", 2370, 70)
{
 z=340;
};
R_Date("Beta-18422", 1840, 60)
{
 z=257;
};
R_Date("Beta-18423", 1210, 70)
{
 z=201;
};
R_Date("Beta-18424", 870, 60)
{
 z=105;
};
R_Date("Beta-18425", 270, 70)
{
```

```
   z=50;
  };
  Boundary("t")
  {
   z=0;
  };
 };
 Difference("", "Derragh Bog Plantago Rise", "Derragh Bog Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 108.8 Aoverall 109.1				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Derragh Bog	-2	2	68.2	-2	2	95.4	-1.20436	-0.68836	68.2	-1.47236	-0.48036	95.4		100			99.6
b							-4573	-4229	68.2	-4806	-4087	95.4					99.4
Beta-18414	-4319	-4058	68.2	-4341	-3994	95.4	-4311	-4066	68.2	-4339	-3997	95.4		101.6			99.8
Beta-18415	-3651	-3521	68.2	-3702	-3378	95.4	-3646	-3526	68.2	-3701	-3416	95.4		109.3			99.9
Derragh Bog Elm Decline							-3627	-3487	68.2	-3654	-3405	95.4					99.9
Derragh Bog Plantago Rise							-3558	-3389	68.2	-3616	-3376	95.4					99.7
Beta-18416	-3636	-3383	68.2	-3651	-3371	95.4	-3540	-3376	68.2	-3604	-3367	95.4		93			99.7
End Plantago Curve							-3452	-3230	68.2	-3570	-3115	95.4					99.8
Beta-18417	-3265	-2918	68.2	-3335	-2906	95.4	-3071	-2927	68.2	-3264	-2898	95.4		113			99.9
Beta-18418	-2926	-2680	68.2	-3080	-2622	95.4	-2938	-2759	68.2	-3024	-2685	95.4		112.3			99.8
Beta-18419	-1957	-1766	68.2	-2118	-1690	95.4	-1951	-1772	68.2	-2036	-1693	95.4		103.5			99.8
Beta-18420	-1191	-940	68.2	-1266	-856	95.4	-1193	-996	68.2	-1259	-911	95.4		103.1			99.9
Beta-18421	-731	-382	68.2	-765	-236	95.4	-732	-397	68.2	-755	-377	95.4		97.4			99.9
Beta-18422	87	242	68.2	52	335	95.4	93	248	68.2	66	331	95.4		102.6			99.9
Beta-18423	696	891	68.2	671	970	95.4	665	784	68.2	651	876	95.4		92.3			99.9
Beta-18424	1047	1241	68.2	1035	1260	95.4	1164	1257	68.2	1067	1275	95.4		101.6			99.9
Beta-18425	1492	...	68.2	1449	...	95.5	1501	1794	68.2	1450	1953	95.4		104.6			99.8
t							1777	2222	68.2	1605	2538	95.4					99.1
Derragh Bog Plantago Rise,Derragh Bog Elm Decline							-2	69	68.2	-2	153	95.4					99.4

Table C.31 OxCal P_Sequence model for Derragh Bog

C.4.13. OxCal *P_Sequence* model for Fallahogy (Smith 1957; Smith and Willis 1961)

```
Plot()
 {
  P_Sequence("Fallahogy",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=307;
   };
   R_Combine()
   {
    z=277;
    R_Date("Q-555", 5110, 120);
    R_Date(5330, 120);
   };
   R_Combine()
   {
    z=273;
    R_Date("Q-653", 5190, 120);
    R_Date(5270, 120);
   };
   Date("Fallahogy Elm Decline")
   {
    z=272;
   };
   Date("Fallahogy Plantago Rise")
   {
    z=270;
   };
   R_Date("Q-556", 5290, 120)
   {
    z=266;
   };
   R_Date("Q-557", 5260, 120)
   {
    z=264;
   };
   R_Date("Q-654", 4860, 120)
   {
    z=256;
   };
   R_Combine()
   {
    z=120;
    R_Date("Q-558", 4480, 120);
    R_Date(4390, 120);
    R_Date(4540, 120);
   };
```

```
  Boundary("t")
  {
   z=0;
  };
 };
 Difference("", "Fallahogy Plantago Rise", "Fallahogy Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 84.6 Aoverall 84.8				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Fallahogy	-2	2	68.2	-2	2	95.4	-0.4449	1.8551	68.2	-1.2889	2.0071	95.4		100			96.9
Boundary b							-4276	-4134	68.2	-4423	-4031	95.4					98.9
R_Combine(5222,85)	-4228	-3959	68.2	-4314	-3803	95.4	-4076	-4005	68.2	-4167	-3971	95.4		126.4			99.8
R_Combine(5230,85)	-4228	-3963	68.2	-4319	-3806	95.4	-4052	-3989	68.2	-4143	-3960	95.4		133.5			99.8
Fallahogy Elm Decline							-4046	-3985	68.2	-4138	-3955	95.4					99.8
Fallahogy Plantago Rise							-4036	-3976	68.2	-4126	-3945	95.4					99.8
R_Date Q-556	-4246	-3986	68.2	-4356	-3804	95.4	-4015	-3960	68.2	-4102	-3926	95.4		92.1			99.7
R_Date Q-557	-4237	-3969	68.2	-4341	-3800	95.4	-4005	-3950	68.2	-4091	-3911	95.4		100.1			99.7
R_Date Q-654	-3791	-3387	68.2	-3944	-3373	95.4	-3958	-3901	68.2	-4041	-3767	95.4		40.2			99.8
R_Combine(4471,70)	-3335	-3030	68.2	-3358	-2930	95.4	-3347	-3044	68.2	-3363	-2930	95.4		100.5			99.3
Boundary t							-2833	-2301	68.2	-3088	-1963	95.4					96.6
Fallahogy Plantago Rise,Fallahogy Elm Decline							-2	15	68.2	-2	27	95.4					98.9

Table C.32 OxCal P_Sequence model for Fallahogy

C.4.14. OxCal *P_Sequence* model for Garrynagran (Jennings 1997)

```
Plot()
 {
  P_Sequence("Garrynagran",1,0.1,U(-2,2))
  {
   Boundary();
   R_Date("GrN-22182",6480,50)
   {
    z=179;
   };
   Date("Garrynagran Elm Decline")
   {
    z=124;
   };
   R_Date("GrN-21814",5010,60)
   {
    z=119;
   };
   Date("Garrynagran Plantago")
   {
    z=118;
   };
   R_Date("GrN-21815",4510,60)
   {
    z=93;
   };
   Date("Garrynagran End Plantago")
   {
    z=92;
   };
   R_Date("GrN-21816",4350,50)
   {
    z=69;
   };
   R_Date("GrN-22183",4090,50)
   {
    z=51;
   };
   R_Date("GrN-22184",3730,40)
   {
    z=35;
   };
   Boundary();
  };
  Difference("", "Garrynagran Plantago", "Garrynagran Elm Decline");
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 102.5 Aoverall 102.2				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Garrynagran	-2	2	68.2	-2	2	95.4	-0.80727	-0.01127	68.2	-1.12727	0.396727	95.4		100			98.7
							-5484	-5373	68.2	-5520	-5326	95.4					99.7
GrN-22182	-5485	-5376	68.2	-5529	-5331	95.4	-5484	-5373	68.2	-5520	-5326	95.4		98.7			99.7
Garrynagran Elm Decline							-4091	-3866	68.2	-4200	-3726	95.4					98.9
GrN-21814	-3936	-3709	68.2	-3953	-3666	95.4	-3950	-3761	68.2	-3961	-3704	95.4		99.4			99.2
Garrynagran Plantago							-3934	-3753	68.2	-3953	-3669	95.4					99.1
GrN-21815	-3346	-3105	68.2	-3486	-3017	95.4	-3368	-3258	68.2	-3493	-3124	95.4		100.3			99.3
Garrynagran End Plantago							-3357	-3237	68.2	-3483	-3101	95.4					99.2
GrN-21816	-3019	-2907	68.2	-3262	-2886	95.4	-2981	-2899	68.2	-3080	-2883	95.4		110.3			99.8
GrN-22183	-2853	-2505	68.1	-2871	-2490	95.4	-2660	-2496	68.2	-2752	-2474	95.4		100.4			99.6
GrN-22184	-2199	-2042	68.2	-2281	-1985	95.3	-2204	-2052	68.2	-2284	-2031	95.4		97.4			99.7
							-2204	-2052	68.2	-2284	-2031	95.4					99.7
Garrynagran Plantago,Garrynagran Elm Decline							32	203	68.2	-2	366	95.4					98.8

Table C.33 OxCal P_Sequence model for Garrynagran

C.4.15. OxCal *P_Sequence* model for Glenulra Basin (Molloy and O'Connell 1995b; O'Connell and Molloy 2001)

```
Plot()
 {
  P_Sequence("Glenulra Basin",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=583;
   };
   R_Date("GrN-21630", 5100, 80)
   {
    z=517;
   };
   Date("Glenulra Basin Plantago Rise")
   {
    z=498;
    color="Green";
   };
   R_Date("GrN-21631", 5170, 112)
   {
    Outlier();
    z=496;
   };
   Date("Glenulra Basin Elm Decline")
   {
    z=494;
   };
   R_Date("Grn-21117", 4840, 60)
   {
    z=488;
   };
   R_Date("GrN-21632", 4500, 60)
   {
    z=461;
   };
   R_Date("GrN-21118", 4550, 60)
   {
    z=450;
   };
   R_Date("GrN-21633", 4470, 60)
   {
    z=442;
   };
   R_Date("GrN-21119", 4110, 60)
   {
    z=404;
   };
   R_Date("GrN-21634", 4070, 60)
```

```
 {
  z=389;
 };
 R_Date("GrN-21120", 3890, 60)
 {
  z=353;
 };
 R_Date("GrN-21635", 3510, 50)
 {
  z=321;
 };
 R_Date("GrN-21121", 3310, 60)
 {
  z=291;
 };
 R_Date("GrN-21636", 2890, 50)
 {
  z=257;
 };
 R_Date("GrN-21637", 1940, 50)
 {
  z=187;
 };
 R_Date("GrN-21638", 1820, 50)
 {
  z=169;
 };
 Boundary("t")
 {
  z=81;
 };
};
Difference("", "Glenulra Basin Elm Decline", "Glenulra Basin Plantago Rise");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 109.3 Aoverall 109.9				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Glenlura Basin	-2	2	68.2	-2	2	95.4	-0.85658	-0.22058	68.2	-1.15658	0.063416	95.4		100			97.9
Boundary b							-4875	-4434	68.2	-5175	-4182	95.4					96.6
R_Date GrN-21630	-3972	-3797	68.2	-4053	-3696	95.4	-3972	-3819	68.2	-4046	-3751	95.4		107			99.6
Glenlura Basin Plantago Rise							-3775	-3629	68.2	-3848	-3562	95.4					99.4
R_Date GrN-21631	-4223	-3800	68.2	-4254	-3711	95.4	-4224	-3800	68.1	-4255	-3711	95.4				1.9	99.3
Glenlura Basin Elm Decline							-3725	-3587	68.2	-3797	-3540	95.4					99.6
R_Date Grn-21117	-3696	-3532	68.2	-3766	-3384	95.4	-3663	-3531	68.2	-3707	-3517	95.4		107.2			99.7
R_Date GrN-21632	-3340	-3101	68.2	-3369	-2945	95.5	-3357	-3260	68.2	-3371	-3172	95.4		107.3			99.7
R_Date GrN-21118	-3368	-3107	68.1	-3499	-3030	95.4	-3236	-3130	68.2	-3311	-3095	95.4		110.6			99.8
R_Date GrN-21633	-3334	-3030	68.3	-3355	-2934	95.4	-3181	-3050	68.2	-3267	-3008	95.4		102.6			99.7
R_Date GrN-21119	-2859	-2579	68.2	-2878	-2496	95.4	-2841	-2665	68.2	-2873	-2616	95.4		103			99.7
R_Date GrN-21634	-2850	-2492	68.1	-2866	-2473	95.4	-2672	-2506	68.2	-2746	-2481	95.4		111.9			99.6
R_Date GrN-21120	-2465	-2296	68.2	-2564	-2155	95.4	-2347	-2202	68.2	-2430	-2143	95.4		79.2			99.6
R_Date GrN-21635	-1894	-1759	68.2	-1961	-1692	95.4	-1916	-1801	68.2	-1962	-1746	95.4		103.2			99.6
R_Date GrN-21121	-1658	-1512	68.2	-1741	-1451	95.4	-1612	-1500	68.2	-1665	-1439	95.4		100.8			99.7
R_Date GrN-21636	-1190	-1001	68.2	-1217	-929	95.4	-1127	-1000	68.2	-1206	-936	95.4		105.9			99.7
R_Date GrN-21637	6	125	68.2	-48	212	95.4	-38	75	68.2	-88	131	95.4		96.3			99.7
R_Date GrN-21638	128	251	68.2	78	332	95.4	136	245	68.2	93	326	95.4		106.6			99.8
Boundary t							975	1460	68.2	710	1789	95.4					98.6
Glenulra Basin Elm Decline,Glenulra Basin Plantago Rise							-2	50	68.2	-2	117	95.4					99.5

Table C.34 OxCal P_Sequence model for Glenulra Basin

C.4.16. OxCal *P_Sequence* model for Lough Dargan (Taylor *et al.* 2013; Ghilardi and O'Connell 2013)

```
Plot()
 {
  P_Sequence("Lough Dargan",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=636;
   };
   R_Date("GrA-45449", 5110, 50)
   {
    z=578;
   };
   Date("Lough Dargan Elm Decline")
   {
    z=576;
   };
   Date("Lough Dargan Plantago Rise")
   {
    z=572;
   };
   R_Date("GrA-45446", 4665, 110)
   {
    z=560;
   };
   Date("Lough Dargan End Plantago")
   {
    z=552;
   };
   R_Date("GrA-45444", 4150, 60)
   {
    z=540;
   };
   R_Date("UBA-15782", 3889, 29)
   {
    z=522;
   };
   R_Date("GrA-45443", 3780, 105)
   {
    z=520;
   };
   R_Date("GrA-45442", 3850, 40)
   {
    z=500;
   };
   R_Date("GrA-45439", 3440, 205)
   {
    z=478;
```

```
 };
 R_Date("UBA-15781", 3366, 41)
 {
  z=470;
 };
 R_Date("GrA-45437", 3075, 220)
 {
  z=460;
 };
 R_Date("GrA-45435", 2910, 45)
 {
  z=440;
 };
 R_Date("GrA-45433", 2820, 130)
 {
  z=420;
 };
 R_Date("UBA-15780", 2651, 86)
 {
  z=408;
 };
 R_Date("GrA-45432", 2530, 370)
 {
  z=400;
 };
 R_Date("UBA-15778", 1944, 41)
 {
  z=330;
 };
 Boundary("t")
 {
  z=116;
 };
};
Difference("", "Lough Dargan Plantago Rise", "Lough Dargan Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 126.5 Aoverall 126.3				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Lough Dargan	-2	2	68.2	-2	2	95.4	-1.35355	-0.96155	68.2	-1.47755	-0.78555	95.4		100			95.9
Boundary b							-4822	-4132	68.2	-5433	-3932	95.4					95.3
R_Date GrA-45449	-3970	-3805	68.2	-4036	-3785	95.4	-3961	-3798	68.2	-3988	-3772	95.4		100			99.2
Lough Dargan Elm Decline							-3960	-3774	68.2	-3990	-3550	95.4					98.3
Lough Dargan Plantago Rise							-3897	-3599	68.2	-3972	-3377	95.4					97.7
R_Date GrA-45446	-3634	-3347	68.2	-3658	-3091	95.4	-3632	-3347	68.2	-3649	-3100	95.4		101.6			99.4
R_Date GrA-45444	-2872	-2637	68.1	-2888	-2577	95.4	-2873	-2667	68.2	-2886	-2580	95.4		100.9			99.5
R_Date UBA-15782	-2456	-2346	68.2	-2467	-2292	95.4	-2463	-2375	68.2	-2468	-2309	95.4		105.3			99.1
R_Date GrA-45443	-2400	-2036	68.2	-2487	-1923	95.4	-2458	-2342	68.2	-2466	-2287	95.4		86.6			98.8
R_Date GrA-45442	-2437	-2210	68.1	-2461	-2204	95.4	-2330	-2206	68.2	-2402	-2146	95.4		99.6			99.2
R_Date GrA-45439	-2022	-1505	68.2	-2346	-1264	95.4	-1867	-1634	68.2	-2104	-1560	95.4		127.5			99.1
R_Date UBA-15781	-1735	-1616	68.2	-1751	-1531	95.4	-1731	-1616	68.2	-1747	-1534	95.4		101.5			99.8
R_Date GrA-45437	-1602	-1019	68.2	-1877	-814	95.4	-1631	-1334	68.2	-1691	-1157	95.4		110.9			99.4
R_Date GrA-45435	-1192	-1021	68.2	-1231	-945	95.4	-1196	-1051	68.2	-1258	-1001	95.4		101.1			99.6
R_Date GrA-45433	-1155	-832	68.2	-1390	-788	95.4	-1024	-860	68.2	-1112	-809	95.4		120.4			99.8
R_Date UBA-15780	-968	-672	68.2	-1012	-540	95.4	-905	-785	68.2	-1005	-595	95.4		117.3			99.7
R_Date GrA-45432	-1112	-202	68.2	-1608	213	95.4	-888	-671	68.2	-966	-478	95.4		134.3			99
R_Date UBA-15778	16	121	68.2	-45	134	95.4	2	114	68.2	-42	129	95.4		99.5			99.8
Boundary t							1671	2002	68.2	1222	2007	95.4					98.4
Lough Dargan Plantago Rise,Lough Dargan Elm Decline							-2	125	68.2	-2	360	95.4					99.2

Table C.35 OxCal P_Sequence model for Lough Dargan

C.4.17. OxCal *P_Sequence* model for Loughmeenaghan (Stolze 2012b; Stolze *et al.* 2012)

```
Plot()
 {
  P_Sequence("Loughmeenaghan",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=710;
   };
   R_Date("KIA-40913", 5389, 77)
   {
    z=705;
   };
   R_Date("KIA-40914", 5122, 52)
   {
    z=696;
   };
   Date("Loughmeenaghan Elm Decline")
   {
    z=693;
   };
   R_Date("KIA-40915", 4935, 29)
   {
    z=687;
   };
   Date("Loughmeenaghan Plantago Rise")
   {
    z=686;
   };
   R_Date("KIA-43112", 5813, 85)
   {
    Outlier();
    z=682;
   };
   R_Date("KIA-40921", 4809, 24)
   {
    z=676;
   };
   R_Date("KIA-49016", 4791, 30)
   {
    z=675;
   };
   Date("Loughmeenaghan end Plantago")
   {
    z=671;
   };
   R_Date("KIA-40917", 4829, 79)
   {
```

```
  z=670;
 };
 R_Date("KIA-43367", 4622, 45)
 {
  z=665;
 };
 R_Date("KIA-40918", 4542, 35)
 {
  z=660;
 };
 R_Date("KIA-43114", 4755, 35)
 {
  Outlier();
  z=649;
 };
 R_Date("KIA-40919", 4212, 59)
 {
  Outlier();
  z=642;
 };
 R_Date("KIA-40920", 4392, 43)
 {
  z=635;
 };
 R_Date("KIA-43113", 5295, 35)
 {
  Outlier();
  z=615;
 };
 R_Date("KIA-43366", 4306, 87)
 {
  Outlier();
  z=604;
 };
 Boundary("t")
 {
  z=610;
 };
};
Difference("", "Loughmeenaghan Plantago Rise", "Loughmeenaghan Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 82.1 Aoverall 75.6				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Loughmeenaghan	-2	2	68.2	-2	2	95.4	-0.78606	0.337943	68.2	-0.90606	1.59794	95.4		100			95.6
b							-4200	-4049	68.2	-4360	-4011	95.4					98.7
KIA-40913	-4336	-4075	68.2	-4361	-4001	95.4	-4125	-3984	68.2	-4260	-3963	95.4		62.6			99.3
KIA-40914	-3979	-3806	68.2	-4040	-3791	95.4	-3966	-3836	68.2	-3986	-3806	95.4		100.9			99.6
Loughmeenaghan Elm Decline							-3890	-3788	68.2	-3953	-3743	95.4					99.7
KIA-40915	-3759	-3658	68.2	-3774	-3653	95.4	-3771	-3695	68.2	-3785	-3664	95.4		85.2			99.7
Loughmeenaghan Plantago Rise							-3757	-3687	68.2	-3777	-3651	95.4					99.7
KIA-43112	-4769	-4551	68.2	-4876	-4461	95.4	-4768	-4553	68.2	-4878	-4461	95.4					99.7
KIA-40921	-3643	-3536	68.1	-3650	-3527	95.4	-3640	-3542	68.2	-3646	-3535	95.4		88.4			99.8
KIA-49016	-3638	-3533	68.2	-3646	-3521	95.4	-3634	-3534	68.2	-3641	-3523	95.4		110.9			99.7
Loughmeenaghan end Plantago							-3561	-3467	68.2	-3602	-3422	95.4					99.1
KIA-40917	-3701	-3522	68.2	-3781	-3376	95.4	-3554	-3451	68.2	-3585	-3403	95.4		70			99
KIA-43367	-3501	-3352	68.2	-3623	-3130	95.4	-3476	-3361	68.2	-3498	-3352	95.4		95.7			99.5
KIA-40918	-3363	-3119	68.2	-3366	-3103	95.4	-3366	-3323	68.2	-3375	-3201	95.4		105			99.8
KIA-43114	-3633	-3521	68.2	-3639	-3381	95.4	-3633	-3521	68.2	-3639	-3381	95.4				0.1	99.9
KIA-40919	-2900	-2695	68.2	-2917	-2621	95.4	-2900	-2694	68.2	-2917	-2621	95.4				0.8	99.7
KIA-40920	-3087	-2924	68.2	-3320	-2903	95.4	-3021	-2922	68.2	-3087	-2910	95.4		111.4			99.5
KIA-43113	-4227	-4049	68.2	-4236	-4001	95.4	-4227	-4049	68.2	-4237	-4001	95.4					99.9
KIA-43366	-3091	-2778	68.2	-3329	-2636	95.4	-3090	-2778	68.2	-3330	-2635	95.4				57.6	99.7
t							-2732	-2487	68.2	-2915	-2281	95.4					98.4
Loughmeenaghan Plantago Rise,Loughmeenaghan Elm Decline							75	162	68.2	29	244	95.4					99.2

Table C.36 OxCal P_Sequence model for Loughmeenaghan

C.4.18. OxCal *P_Sequence* model for Lough Muckno (Chique *et al.* 2017)

```
Plot()
 {
  P_Sequence("Lough Muckno",1,0.1,U(-2,2))
  {
   Boundary();
   R_Date("Lough Muckno Elm Decline (UBA-26864)",5174,40)
   {
    z=708;
   };
   Date("Lough Muckno Plantago")
   {
    z=692;
   };
   Date("Lough Muckno End Plantago")
   {
    z=672;
   };
   R_Date("UBA-26863",4237,37)
   {
    z=628;
   };
   R_Date("UBA-26862",3119,32)
   {
    z=492;
   };
   R_Date("UBA-29463",2348,46)
   {
    z=420;
   };
   R_Date("UBA-29462",1472,30)
   {
    z=372;
   };
   R_Date("UBA-30293",1108,34)
   {
    z=320;
   };
   R_Date("UBA-26861",1494,36)
   {
    Outlier();
    z=301;
   };
   R_Date("UBA-26860",756,31)
   {
    z=160;
   };
   Boundary();
  };
  Difference("", "Lough Muckno Plantago", "Lough Muckno Elm Decline (UBA-26864)");
 };
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 97.5 Aoveral l 97.3				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Lough Muckno	-2	2	68.2	-2	2	95.4	- 1.86568	- 1.55768	68.2	- 1.91368	- 1.35368	95.4		100			99.2
Boundary							-4039	-3954	68.2	-4051	-3805	95.4					98.7
R_Date Elm Decline/UBA-26864	-4039	-3956	68.2	-4052	-3811	95.4	-4039	-3954	68.2	-4051	-3805	95.4		95			98.7
Lough Muckno Plantago							-4040	-3668	68.2	-4048	-3044	95.4					96
R_Date UBA-26863	-2905	-2763	68.2	-2917	-2694	95.4	-2906	-2774	68.2	-2917	-2695	95.4		101.7			99.3
R_Date UBA-26862	-1431	-1311	68.2	-1451	-1288	95.4	-1431	-1309	68.2	-1451	-1286	95.4		99.3			99.5
R_Date UBA-29463	-507	-379	68.2	-735	-235	95.4	-490	-377	68.2	-733	-235	95.4		101.1			99.4
R_Date UBA-29462	565	621	68.2	544	644	95.4	564	621	68.2	544	645	95.4		99.8			99.4
R_Date UBA-30293	895	980	68.2	779	1018	95.4	890	972	68.2	776	1000	95.4		94.7			99.3
R_Date UBA-26861	540	615	68.2	431	645	95.4	541	614	68.2	431	645	95.4					99.5
R_Date UBA-26860	1248	1281	68.2	1220	1285	95.4	1249	1282	68.2	1221	1287	95.4		101			99.6
Boundary							1249	1282	68.2	1221	1287	95.4					99.6
Lough Muckno Plantago,Lough Muckno Elm Decline (UBA-26864)							-2	294	68.2	-2	843	95.4					95.1

Table C.37 OxCal P_Sequence model for Lough Muckno

C.4.19. OxCal *P_Sequence* model for Lough Sheeauns (Molloy and O'Connell 1991)

```
Plot()
 {
  P_Sequence("Lough Sheeauns",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=582;
   };
   R_Date("GrN-14495", 9270, 100)
   {
    z=576;
   };
   R_Date("GrN-14496", 6910, 90)
   {
    z=505;
   };
   R_Date("GrN-14039", 5340, 45)
   {
    z=454;
   };
   Date("Lough Sheeauns Plantago Rise")
   {
    z=442;
    color="Green";
   };
   R_Date("GrN-14040", 5110, 70)
   {
    z=438;
   };
   Date("Lough Sheeauns Elm Decline")
   {
    z=433;
   };
   R_Date("GrN-14041", 4920, 45)
   {
    z=422;
   };
   R_Date("GrN-14042", 4870, 60)
   {
    z=406;
   };
   Date("Lough Sheeauns End Plantago")
   {
    z=402;
   };
   R_Date("GrN-14501", 4660, 40)
   {
```

```
  z=392;
 };
 R_Date("GrN-14497", 4500, 70)
 {
  z=360;
 };
 R_Date("GrN-14502", 3940, 60)
 {
  z=320;
 };
 R_Date("GrN-14503", 2870, 60)
 {
  z=296;
 };
 R_Date("GrN-14498", 2340, 50)
 {
  z=252;
 };
 R_Date("GrN-14499", 1970, 60)
 {
  z=236;
 };
 R_Date("GrN-14500", 2400, 80)
 {
  Outlier();
  z=216;
 };
 Boundary("t")
 {
  z=202;
 };
};
Difference("", "Lough Sheeauns Elm Decline", "Lough Sheeauns Plantago Rise");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 100.6 Aoverall 101.1				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
P_Sequence Lough Sheeauns	-2	2	68.2	-2	2	95.4	-1.31169	-0.95569	68.2	-1.42369	-0.79169	95.4		100			99.6
Boundary b							-8692	-8344	68.2	-9081	-8285	95.4					97.3
R_Date GrN-14495	-8621	-8347	68.2	-8746	-8291	95.4	-8554	-8312	68.2	-8716	-8282	95.4		101.8			99
R_Date GrN-14496	-5892	-5717	68.2	-5984	-5648	95.4	-5892	-5718	68.2	-5984	-5656	95.4		100.2			99.9
R_Date GrN-14039	-4254	-4064	68.1	-4324	-4046	95.4	-4251	-4062	68.2	-4322	-4046	95.4		100.4			99.9
Lough Sheeauns Plantago Rise							-4049	-3842	68.2	-4186	-3781	95.4					99.8
R_Date GrN-14040	-3975	-3800	68.2	-4044	-3713	95.4	-3976	-3805	68.2	-4045	-3765	95.4		103.5			99.9
Lough Sheeauns Elm Decline							-3928	-3755	68.2	-3996	-3681	95.4					99.8
R_Date GrN-14041	-3760	-3649	68.2	-3787	-3640	95.4	-3765	-3663	68.2	-3790	-3647	95.4		95.6			99.9
R_Date GrN-14042	-3712	-3537	68.2	-3789	-3522	95.4	-3696	-3536	68.2	-3716	-3521	95.4		106.2			100
R_Date GrN-14501	-3512	-3370	68.2	-3624	-3360	95.4	-3517	-3425	68.2	-3625	-3363	95.4		100.3			99.9
R_Date GrN-14497	-3344	-3099	68.2	-3483	-2932	95.4	-3277	-3027	68.2	-3353	-2935	95.4		98.6			99.9
R_Date GrN-14502	-2563	-2343	68.2	-2581	-2210	95.4	-2489	-2301	68.2	-2574	-2209	95.4		98.4			99.8
R_Date GrN-14503	-1125	-936	68.2	-1223	-901	95.4	-1194	-989	68.2	-1257	-913	95.4		96.8			99.9
R_Date GrN-14498	-507	-366	68.2	-737	-211	95.4	-485	-363	68.2	-544	-209	95.4		105			99.8
R_Date GrN-14499	-45	86	68.2	-162	209	95.4	-51	84	68.2	-167	133	95.4		97.6			99.8
R_Date GrN-14500	-746	-396	68.3	-782	-364	95.4	-746	-396	68.2	-782	-364	95.4					99.8
Boundary t							142	962	68.2	-31	1857	95.4					97.8
Lough Sheeauns Elm Decline,Lough Sheeauns Plantago Rise							-2	161	68.2	-2	339	95.4					98.3

Table C.38 OxCal P_Sequence model for Lough Sheeauns

C.4.20. OxCal *P_Sequence* model for Templevanny Lough (Stolze 2012b; Stolze *et al.* 2013a; 2013b)

```
Plot()
 {
  P_Sequence("Templevanny Lough",1,0.01,U(-2,2))
  {
   Boundary(b)
   {
    z=1000;
   };
   R_Date("KIA-43362", 5273, 41)
   {
    z=998;
   };
   R_Date("KIA-40922", 4967, 40)
   {
    Outlier();
    z=995;
   };
   Date("Templevanny Lough Elm Decline")
   {
    z=988;
   };
   R_Date("KIA-40923", 5220, 46)
   {
    Outlier();
    z=988;
   };
   R_Date("KIA-40924", 5000, 31)
   {
    z=984;
   };
   Date("Templevanny Lough Plantago Rise")
   {
    z=980;
   };
   R_Date("KIA-40925", 5436, 58)
   {
    Outlier();
    z=979;
   };
   R_Date("KIA-40926", 5057, 48)
   {
    Outlier();
    z=973;
   };
   R_Date("KIA-43111", 5335, 56)
   {
    Outlier();
```

```
   z=964;
  };
  R_Date("KIA-40927", 4721, 30)
  {
   z=956;
  };
  R_Date("KIA-43363", 4851, 79)
  {
   Outlier();
   z=949;
  };
  Date("Templevanny Lough End Plantago")
  {
   z=944;
  };
  R_Date("KIA-40932", 4533, 70)
  {
   z=942;
  };
  R_Date("KIA-43364", 4510, 32)
  {
   z=926;
  };
  R_Date("KIA-40928", 4912, 55)
  {
   Outlier();
   z=923;
  };
  R_Date("KIA-40929", 4545, 58)
  {
   z=909;
  };
  R_Date("KIA-40930", 4316, 55)
  {
   z=896;
  };
  R_Date("KIA-43365", 4497, 65)
  {
   Outlier();
   z=890;
  };
  Boundary("t")
  {
   z=870;
  };
 };
 Difference("", "Templevanny Lough Plantago Rise", "Templevanny Lough Elm Decline");
};
```

Name	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices Amodel 68.6 Aoverall 69.6				
	from	to	%	from	to	%	from	to	%	from	to	%	Acomb	A	L	P	C
Templevanny Lough	-2	2	68.2	-2	2	95.4	-1.03255	1.98745	68.2	-1.05255	1.99945	95.4		100			96.4
b							-4096	-4025	68.2	-4162	-3989	95.4					99.6
KIA-43362	-4227	-4000	68.3	-4233	-3988	95.4	-4073	-4004	68.2	-4141	-3978	95.4		100.5			99.7
KIA-40922	-3790	-3697	68.2	-3927	-3653	95.4	-3789	-3698	68.2	-3924	-3653	95.4				2.3	99.9
Templevanny Lough Elm Decline							-3967	-3913	68.2	-4004	-3790	95.4					99.8
KIA-40923	-4145	-3966	68.2	-4229	-3957	95.4	-4145	-3966	68.2	-4228	-3957	95.3				2.4	99.9
KIA-40924	-3892	-3712	68.2	-3939	-3701	95.4	-3923	-3877	68.2	-3944	-3736	95.4		68.2			99.9
Templevanny Lough Plantago Rise							-3884	-3835	68.2	-3909	-3710	95.4					99.8
KIA-40925	-4345	-4242	68.2	-4444	-4061	95.3	-4345	-4242	68.2	-4443	-4061	95.4					99.9
KIA-40926	-3943	-3798	68.2	-3963	-3715	95.4	-3942	-3798	68.2	-3963	-3715	95.4					99.9
KIA-43111	-4246	-4056	68.2	-4328	-4005	95.4	-4246	-4056	68.2	-4328	-4006	95.4					99.9
KIA-40927	-3627	-3381	68.2	-3633	-3376	95.4	-3630	-3593	68.2	-3636	-3386	95.5		112.6			99.9
KIA-43363	-3711	-3524	68.2	-3894	-3377	95.3	-3712	-3524	68.2	-3894	-3377	95.4				28	99.9
Templevanny Lough End Plantago							-3514	-3466	68.2	-3529	-3303	95.4					99.8
KIA-40932	-3362	-3105	68.1	-3501	-3011	95.4	-3494	-3446	68.2	-3507	-3284	95.4		51.4			99.9
KIA-43364	-3342	-3112	68.2	-3354	-3097	95.4	-3341	-3277	68.2	-3354	-3179	95.4		95.7			99.7
KIA-40928	-3761	-3644	68.2	-3907	-3539	95.4	-3761	-3644	68.2	-3905	-3539	95.4					99.9
KIA-40929	-3366	-3108	68.3	-3497	-3029	95.4	-3159	-3099	68.2	-3205	-3029	95.4		102.8			99.7
KIA-40930	-3011	-2890	68.2	-3098	-2777	95.4	-3030	-2949	68.2	-3082	-2894	95.4		91.9			99.7
KIA-43365	-3341	-3099	68.2	-3368	-2938	95.4	-3341	-3099	68.2	-3368	-2940	95.4				4.9	99.9
t							-2796	-2656	68.2	-2914	-2488	95.4					99
Templevanny Lough Plantago Rise,Templevanny Lough Elm Decline							66	98	68.2	10	165	95.4					98.4

Table C.39 OxCal P_Sequence model for Templevanny Lough

C.4.21. Model of Ireland South "Elm Decline" Difference

```
Plot()
 {
  Prior("Lough_Cullin_Elm_Decline","Lough_Cullin_Elm_Decline.prior");
  Prior("Arderrawinny_Elm_Decline","Arderrawinny_Elm_Decline.prior");
  Prior("Knockadoon_South_Elm_Decline","Knockadoon_South_Elm_Decline.prior");

  Difference("", "Lough_Cullin_Elm_Decline", "Arderrawinny_Elm_Decline");
  Difference("", "Lough_Cullin_Elm_Decline", "Knockadoon_South_Elm_Decline");
};
```

C.4.22. Model of Ireland North "Elm Decline" Difference

```
Plot()
 {
Prior("Weirs_Lough_Elm_Decline_UB_2488","Weirs_Lough_Elm_Decline_UB_2488.
prior");
  Prior("Ballynagilly_Elm_Decline","Ballynagilly_Elm_Decline.prior");
Prior("Lough_Mullaghlahan_Elm_Decline_Q_2849_","Lough_Mullaghlahan_Elm_Dec
line_Q_2849_.prior");
Prior("Lough_Catherine_IV_Elm_Decline_UB_2266","Lough_Catherine_IV_Elm_Dec
line_UB_2266.prior");
  Prior("Beaghmore_Elm_Decline","Beaghmore_Elm_Decline.prior");
  Prior("Fallahogy_Elm_Decline","Fallahogy_Elm_Decline.prior");
Prior("Lough_Muckno_Elm_Decline_UBA_26864_","Lough_Muckno_Elm_Decline_
UBA_26864_.prior");
  Prior("Killymaddy_Lough_Elm_Decline","Killymaddy_Lough_Elm_Decline.prior");
  Prior("Lackan_1_Elm_Decline_UB_801","Lackan_1_Elm_Decline_UB_801.prior");
Prior("Sluggan_Bog1_Elm_Decline_UB_441","Sluggan_Bog1_Elm_Decline_UB_441.
prior");
Prior("Slieve_Gallion_Elm_Decline_UB_275","Slieve_Gallion_Elm_Decline_UB_275.
prior");
  Prior("Ballyscullion_Elm_Decline","Ballyscullion_Elm_Decline.prior");
```

```
Prior("Slieve_Croob_Elm_Decline_UB_833","Slieve_Croob_Elm_Decline_UB_833.prior");
  Difference("", "Ballyscullion_Elm_Decline", "Weirs_Lough_Elm_Decline_UB_2488");
  Difference("", "Ballyscullion_Elm_Decline", "Ballynagilly_Elm_Decline");
  Difference("", "Ballyscullion_Elm_Decline", "Lough_Mullaghlahan_Elm_Decline_Q_2849_");
  Difference("", "Ballyscullion_Elm_Decline", "Lough_Catherine_IV_Elm_Decline_UB_2266");
  Difference("", "Ballyscullion_Elm_Decline", "Beaghmore_Elm_Decline");
  Difference("", "Ballyscullion_Elm_Decline", "Fallahogy_Elm_Decline");
  Difference("", "Ballyscullion_Elm_Decline", "Lough_Muckno_Elm_Decline_UBA_26864_");
  Difference("", "Ballyscullion_Elm_Decline", "Killymaddy_Lough_Elm_Decline");
  Difference("", "Ballyscullion_Elm_Decline", "Sluggan_Bog1_Elm_Decline_UB_441");
  Difference("", "Ballyscullion_Elm_Decline", "Slieve_Gallion_Elm_Decline_UB_275");
  Difference("", "Ballyscullion_Elm_Decline", "Slieve_Croob_Elm_Decline_UB_833");
 };
```

C.4.23. Model of Ireland East "Elm Decline" Difference

```
Plot()
 {
Prior("Kelly_Lough_Elm_Decline_165541","Kelly_Lough_Elm_Decline_165541.prior");
  Prior("ED2_Beta_78893","ED2_Beta_78893.prior");
  Prior("Corlea_9_Elm_Decline_GU_2141","Corlea_9_Elm_Decline_GU_2141.prior");
  Prior("Derragh_Bog_Elm_Decline","Derragh_Bog_Elm_Decline.prior");
Prior("Clownstown_Elm_Decline_NZA_34452_","Clownstown_Elm_Decline_NZA_34452_.prior");
  Difference("", "Kelly_Lough_Elm_Decline_165541", "ED2_Beta_78893");
  Difference("", "Kelly_Lough_Elm_Decline_165541", "Corlea_9_Elm_Decline_GU_2141");
  Difference("", "Kelly_Lough_Elm_Decline_165541", "Derragh_Bog_Elm_Decline");
```

```
  Difference("", "Kelly_Lough_Elm_Decline_165541",
"Clownstown_Elm_Decline_NZA_34452_");
 };
```

C.4.24. Model of Ireland West "Elm Decline" Difference

```
Plot()
 {
Prior("Lough_Namackanbeg_Elm_Decline","Lough_Namackanbeg_Elm_Decline.prior
");
  Prior("Gortalecka_Elm_Decline","Gortalecka_Elm_Decline.prior");
Prior("Treanscrabbagh_Elm_Decline_LU_2239","Treanscrabbagh_Elm_Decline_LU_2
239.prior");
  Prior("Ballygalway_Lough_LU_2224_","Ballygalway_Lough_LU_2224_.prior");
  Prior("Garrynagran_Elm_Decline","Garrynagran_Elm_Decline.prior");
  Prior("Cooney_Lough_Elm_Decline","Cooney_Lough_Elm_Decline.prior");
  Prior("Ballinphuill_2_Elm_Decline","Ballinphuill_2_Elm_Decline.prior");
Prior("Templevanny_Lough_Elm_Decline","Templevanny_Lough_Elm_Decline.prior"
);
  Prior("Lough_Sheeauns_Elm_Decline","Lough_Sheeauns_Elm_Decline.prior");
  Prior("Lough_Dargan_Elm_Decline","Lough_Dargan_Elm_Decline.prior");
Prior("Caheraphuca_Lough_Elm_Decline","Caheraphuca_Lough_Elm_Decline.prior");
  Prior("Loughmeenaghan_Elm_Decline","Loughmeenaghan_Elm_Decline.prior");
  Prior("Lough_Aisling_Elm_Decline","Lough_Aisling_Elm_Decline.prior");
  Prior("Glenulra_Basin_Elm_Decline","Glenulra_Basin_Elm_Decline.prior");
Prior("Connemara_National_Park_Elm_Decline","Connemara_National_Park_Elm_De
cline.prior");
Prior("Crocknaraw_Elm_Decline_GrN_21640","Crocknaraw_Elm_Decline_GrN_2164
0.prior");
  Difference("", "Templevanny_Lough_Elm_Decline",
"Lough_Namackanbeg_Elm_Decline");
  Difference("", "Templevanny_Lough_Elm_Decline", "Gortalecka_Elm_Decline");
  Difference("", "Templevanny_Lough_Elm_Decline",
"Treanscrabbagh_Elm_Decline_LU_2239");
```

```
 Difference("", "Templevanny_Lough_Elm_Decline",
"Ballygalway_Lough_LU_2224_");
 Difference("", "Templevanny_Lough_Elm_Decline", "Garrynagran_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Cooney_Lough_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline", "Ballinphuill_2_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Lough_Sheeauns_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline", "Lough_Dargan_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Caheraphuca_Lough_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Loughmeenaghan_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline", "Lough_Aisling_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Glenulra_Basin_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Connemara_National_Park_Elm_Decline");
 Difference("", "Templevanny_Lough_Elm_Decline",
"Crocknaraw_Elm_Decline_GrN_21640");
 };
```

C.4.25. Model of 'Event' order for the "Elm Decline" in Ireland

```
Plot()
 {

 Prior("Lough_Cullin_Elm_Decline","Lough_Cullin_Elm_Decline.prior");
 Prior("Knockadoon_South_Elm_Decline","Knockadoon_South_Elm_Decline.prior");
 Prior("Arderrawinny_Elm_Decline","Arderrawinny_Elm_Decline.prior");

Prior("Weirs_Lough_Elm_Decline_UB_2488","Weirs_Lough_Elm_Decline_UB_2488.
prior");
 Prior("Ballynagilly_Elm_Decline","Ballynagilly_Elm_Decline.prior");

Prior("Lough_Mullaghlahan_Elm_Decline_Q_2849_","Lough_Mullaghlahan_Elm_Dec
line_Q_2849_.prior");

Prior("Lough_Catherine_IV_Elm_Decline_UB_2266","Lough_Catherine_IV_Elm_Dec
line_UB_2266.prior");
```

```
Prior("Beaghmore_Elm_Decline","Beaghmore_Elm_Decline.prior");
Prior("Fallahogy_Elm_Decline","Fallahogy_Elm_Decline.prior");
Prior("Lough_Muckno_Elm_Decline_UBA_26864_","Lough_Muckno_Elm_Decline_
UBA_26864_.prior");
Prior("Killymaddy_Lough_Elm_Decline","Killymaddy_Lough_Elm_Decline.prior");
Prior("Lackan_1_Elm_Decline_UB_801","Lackan_1_Elm_Decline_UB_801.prior");
Prior("Sluggan_Bog1_Elm_Decline_UB_441","Sluggan_Bog1_Elm_Decline_UB_441.
prior");
Prior("Slieve_Gallion_Elm_Decline_UB_275","Slieve_Gallion_Elm_Decline_UB_275.
prior");
Prior("Ballyscullion_Elm_Decline","Ballyscullion_Elm_Decline.prior");
Prior("Slieve_Croob_Elm_Decline_UB_833","Slieve_Croob_Elm_Decline_UB_833.pr
ior");
Prior("Kelly_Lough_Elm_Decline_165541","Kelly_Lough_Elm_Decline_165541.prior
");
Prior("ED2_Beta_78893","ED2_Beta_78893.prior");
Prior("Corlea_9_Elm_Decline_GU_2141","Corlea_9_Elm_Decline_GU_2141.prior");
Prior("Derragh_Bog_Elm_Decline","Derragh_Bog_Elm_Decline.prior");
Prior("Clownstown_Elm_Decline_NZA_34452_","Clownstown_Elm_Decline_NZA_3
4452_.prior");
Prior("Lough_Namackanbeg_Elm_Decline","Lough_Namackanbeg_Elm_Decline.prior
");
Prior("Gortalecka_Elm_Decline","Gortalecka_Elm_Decline.prior");
Prior("Treanscrabbagh_Elm_Decline_LU_2239","Treanscrabbagh_Elm_Decline_LU_2
239.prior");
Prior("Ballygalway_Lough_LU_2224_","Ballygalway_Lough_LU_2224_.prior");
Prior("Garrynagran_Elm_Decline","Garrynagran_Elm_Decline.prior");
Prior("Cooney_Lough_Elm_Decline","Cooney_Lough_Elm_Decline.prior");
Prior("Ballinphuill_2_Elm_Decline","Ballinphuill_2_Elm_Decline.prior");
Prior("Templevanny_Lough_Elm_Decline","Templevanny_Lough_Elm_Decline.prior"
);
Prior("Lough_Sheeauns_Elm_Decline","Lough_Sheeauns_Elm_Decline.prior");
```

```
 Prior("Lough_Dargan_Elm_Decline","Lough_Dargan_Elm_Decline.prior");

Prior("Caheraphuca_Lough_Elm_Decline","Caheraphuca_Lough_Elm_Decline.prior");
 Prior("Loughmeenaghan_Elm_Decline","Loughmeenaghan_Elm_Decline.prior");
 Prior("Lough_Aisling_Elm_Decline","Lough_Aisling_Elm_Decline.prior");
 Prior("Glenulra_Basin_Elm_Decline","Glenulra_Basin_Elm_Decline.prior");

Prior("Connemara_National_Park_Elm_Decline","Connemara_National_Park_Elm_De
cline.prior");

Prior("Crocknaraw_Elm_Decline_GrN_21640","Crocknaraw_Elm_Decline_GrN_2164
0.prior");
 Order()
 {
  Date("=Lough_Cullin_Elm_Decline");
  Date("=Knockadoon_South_Elm_Decline");
  Date("=Arderrawinny_Elm_Decline");
  Date("=Weirs_Lough_Elm_Decline_UB_2488");
  Date("=Ballynagilly_Elm_Decline");
  Date("=Lough_Mullaghlahan_Elm_Decline_Q_2849_");
  Date("=Lough_Catherine_IV_Elm_Decline_UB_2266");
  Date("=Beaghmore_Elm_Decline");
  Date("=Fallahogy_Elm_Decline");
  Date("=Lough_Muckno_Elm_Decline_UBA_26864_");
  Date("=Killymaddy_Lough_Elm_Decline");
  Date("=Lackan_1_Elm_Decline_UB_801");
  Date("=Sluggan_Bog1_Elm_Decline_UB_441");
  Date("=Slieve_Gallion_Elm_Decline_UB_275");
  Date("=Ballyscullion_Elm_Decline");
  Date("=Slieve_Croob_Elm_Decline_UB_833");
  Date("=Kelly_Lough_Elm_Decline_165541");
  Date("=ED2_Beta_78893");
  Date("=Corlea_9_Elm_Decline_GU_2141");
  Date("=Derragh_Bog_Elm_Decline");
  Date("=Clownstown_Elm_Decline_NZA_34452_");
  Date("=Lough_Namackanbeg_Elm_Decline");
  Date("=Gortalecka_Elm_Decline");
```

```
  Date("=Treanscrabbagh_Elm_Decline_LU_2239");
  Date("=Ballygalway_Lough_LU_2224_");
  Date("=Garrynagran_Elm_Decline");
  Date("=Cooney_Lough_Elm_Decline");
  Date("=Ballinphuill_2_Elm_Decline");
  Date("=Templevanny_Lough_Elm_Decline");
  Date("=Lough_Sheeauns_Elm_Decline");
  Date("=Lough_Dargan_Elm_Decline");
  Date("=Caheraphuca_Lough_Elm_Decline");
  Date("=Loughmeenaghan_Elm_Decline");
  Date("=Lough_Aisling_Elm_Decline");
  Date("=Glenulra_Basin_Elm_Decline");
  Date("=Connemara_National_Park_Elm_Decline");
  Date("=Crocknaraw_Elm_Decline_GrN_21640");
 };
};
```

C.4.25. Model for 'event' order for the initiation of a *Plantago* curve in Ireland

```
Plot()
 {
  Prior("Lough_Cullin_Begin_Plantago","Lough_Cullin_Begin_Plantago.prior");
  Prior("Fallahogy_Plantago_Rise","Fallahogy_Plantago_Rise.prior");
  Prior("Ballyscullion_Plantago_Rise","Ballyscullion_Plantago_Rise.prior");
  Prior("Ballynagilly_Plantago_Rise","Ballynagilly_Plantago_Rise.prior");

Prior("Lackan_1_Plantago_Curve_UB_800","Lackan_1_Plantago_Curve_UB_800.prio
r");

Prior("Clownastown_Plantago_Rise_NZA_34453_","Clownastown_Plantago_Rise_NZ
A_34453_.prior");
  Prior("Derragh_Bog_Plantago_Rise","Derragh_Bog_Plantago_Rise.prior");
```

```
Prior("Lough_Sheeauns_Plantago_Rise","Lough_Sheeauns_Plantago_Rise.prior");
Prior("Ballinphuill_2_Plantago_Rise","Ballinphuill_2_Plantago_Rise.prior");
Prior("Lough_Dargan_Plantago_Rise","Lough_Dargan_Plantago_Rise.prior");
Prior("Garrynagran_Plantago","Garrynagran_Plantago.prior");

Prior("Templevanny_Lough_Plantago_Rise","Templevanny_Lough_Plantago_Rise.pri
or");

Prior("Caheraphuca_Lough_Begin_Plantago_Curve","Caheraphuca_Lough_Begin_Pla
ntago_Curve.prior");
Prior("Glenulra_Basin_Plantago_Rise","Glenulra_Basin_Plantago_Rise.prior");
Prior("CNP_Plantago_Rise","CNP_Plantago_Rise.prior");
Prior("Loughmeenaghan_Plantago_Rise","Loughmeenaghan_Plantago_Rise.prior");
Prior("Cooney_Lough_Plantago_Rise","Cooney_Lough_Plantago_Rise.prior");
Order()
{
 Date("=Lough_Cullin_Begin_Plantago");
 Date("=Fallahogy_Plantago_Rise");
 Date("=Ballyscullion_Plantago_Rise");
 Date("=Ballynagilly_Plantago_Rise");
 Date("=Lackan_1_Plantago_Curve_UB_800");
 Date("=Clownastown_Plantago_Rise_NZA_34453_");
 Date("=Derragh_Bog_Plantago_Rise");
 Date("=Lough_Sheeauns_Plantago_Rise");
 Date("=Ballinphuill_2_Plantago_Rise");
 Date("=Lough_Dargan_Plantago_Rise");
 Date("=Garrynagran_Plantago");
```

```
  Date("=Templevanny_Lough_Plantago_Rise");
  Date("=Caheraphuca_Lough_Begin_Plantago_Curve");
  Date("=Glenulra_Basin_Plantago_Rise");
  Date("=CNP_Plantago_Rise");
  Date("=Loughmeenaghan_Plantago_Rise");
  Date("=Cooney_Lough_Plantago_Rise");
 };
};
```

Appendix D – Palaeoenvironmental sites excluded from analysis

Site	County	Reason for omission
Agher	Meath	No Radiocarbon dates
Aghla Beg	Donegal	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Altar Lough	Donegal	PDE exceeds threshold
Altnahinch	Antrim	PDE exceeds threshold
An Loch Mór, Inis Oírr	Galway	No Radiocarbon dates published
Annaholty	Tipperary	No Radiocarbon dates
Aranmore Island A	Donegal	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Ardlow Inn	Cavan	No Radiocarbon dates
Ards Beg	Donegal	No Radiocarbon dates
Arts Lough	Wicklow	Elm Decline evident but no information about depth
Aughrim	Kerry	No Radiocarbon dates
Ballinderry	Offaly	No obvious Elm Decline, possible slow accumulation rates in period
Ballinloghig Lake	Kerry	PDE exceeds threshold
Ballyally Lough	Cork	No Radiocarbon dates
Ballyarnet	Derry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Ballycotton	Cork	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Ballydoo Bog	Galway	PDE exceeds threshold
Ballyduff Bog	Tipperary	No obvious Elm Decline
Ballydugan	Down	No Radiocarbon dates
Ballymacombs More Bog	Derry	No Radiocarbon dates
Ballynahatty	Down	PDE exceeds threshold
Ballynakill	Westmeath	No Radiocarbon dates
Ballyness	Donegal	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Ballypatrick Forest2	Antrim	No Radiocarbon dates
Ballyscullion1	Antrim	No Radiocarbon dates
Bann Estuary	Derry	No Radiocarbon dates
Belderg3	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Black Bog	Down	No Radiocarbon dates
Black Lough	Offaly	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Bog of Cullen	Tipperary	Multiple Date Inversion
Borheen Lough	Tipperary	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Brackloon Hollow A	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Brackloon Lough	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Bray Top	Kerry	No Elm Decline noted

Bray West Bog Embayment	Kerry	No Elm Decline noted
Breaghwy	Mayo	No Radiocarbon dates
Brendan Rock-knoll	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Brockley, Rathlin Island	Antrim	Unable to access information
Broghan Bog	Tyrone	No Radiocarbon dates
Butter Mountain2	Down	No Radiocarbon dates
Cadogan's Bog	Cork	No obvious Elm Decline, low values of elm
Caheraphuca Bog	Clare	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Caherkine Lough	Clare	No Radiocarbon dates
Caislean	Mayo	No Elm Decline noted
Camillan1	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Canbo	Roscommon	No Radiocarbon dates
Cannons Lough	Derry	No Radiocarbon dates
Carrivmoragh	Down	PDE exceeds threshold
Carron	Clare	No Radiocarbon dates
Carrowreagh	Roscommon	No Radiocarbon dates
Cashelkeelty	Kerry	PDE exceeds threshold
Castlebog	Down	No Radiocarbon dates
Castlelackan Demesne	Mayo	No Radiocarbon dates
Church Lough	Galway	Hiatus, No dates pre-4200±100
Clonmass Estuary A	Donegal	No Information provided
Clonsast	Offaly	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Cloonacool	Sligo	No Radiocarbon dates
Cloonamore	Galway	No Radiocarbon dates
Cloonlara	Mayo	No Radiocarbon dates
Cloughmills	Antrim	No Radiocarbon dates
Clynacartan Bog	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Cordal	Kerry	No Radiocarbon dates
Corlona	Leitrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Cornaher Lough	Westmeath	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Corslieve Lough	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Coumenare	Kerry	No Radiocarbon dates
Cregganmore	Mayo	No Radiocarbon dates
Crinnagh River	Kerry	No Radiocarbon dates
Croaghaun East	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Crockalough	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Cronalaght	Donegal	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling

Cushendun	Antrim	No Radiocarbon dates
Dereen	Clare	No Radiocarbon dates
Derragh Lough	Longford	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Derrycassan	Cavan	No Radiocarbon dates
Derrycunihy1	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Derrycunihy2	Kerry	No Radiocarbon dates
Derryfadda Lower	Mayo	No Radiocarbon dates
Derryinver Hill	Galway	No dates for Neolithic
Derrytagh North	Armagh	No Radiocarbon dates
Dolan	Galway	No Radiocarbon dates
Doo Lough1	Kerry	No Radiocarbon dates
Doo Lough2	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Doon Lough	Leitrim	No Radiocarbon dates
Douglas Top	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Dromsallagh	Limerick	No Radiocarbon dates
Drummacaladerry	Donegal	No Radiocarbon dates
Dunshaughlin1	Meath	No Radiocarbon dates
Dunshaughlin2	Meath	No Radiocarbon dates
Edentobber	Louth	No Radiocarbon dates
Emlagh Bog Embayment, Kerry	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Emlaghlea Bog	Kerry	No Radiocarbon dates
Essexford Lough	Louth	No Informatio provided
Faunarooska	Clare	No Radiocarbon dates
Galway's Bridge	Kerry	No Radiocarbon dates
Garry Bog1	Antrim	Depth information not published
Glaisín na Marbh	Kerry	No obvious Elm decline
Glenballyemon	Antrim	No Radiocarbon dates
Glendalough	Wicklow	No Informatio provided
Gortagenerick	Cork	No Radiocarbon dates
Gortcorbies	Derry	No Informatio provided
Grillagh	Longford	No Radiocarbon dates
Imlagh	Kerry	No Radiocarbon dates
Imlagh Basin	Kerry	No Radiocarbon dates
Kilmoyly	Kerry	No Radiocarbon dates
Knockasarnet	Kerry	No Radiocarbon dates
Knocknacran1	Monaghan	No Radiocarbon dates
Ladies' View	Kerry	No Radiocarbon dates
Lisnolan	Mayo	No Radiocarbon dates
Littleton Bog	Tipperary	No Radiocarbon dates
Lough Anaffrin	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Lough Anarry	Leitrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling

Lough Anelteen	Sligo	No dating information provided
Lough Avullin	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Lough Beag	Cork	No obvious Elm Decline
Lough Camclaun	Kerry	PDE exceeds threshold
Lough Clevala	Mayo	No Elm Decline noted
Lough Doo	Mayo	PDE exceeds threshold
Lough Fark	Mayo	No Radiocarbon dates
Lough Gowlanagower	Galway	Hiatus
Lough Gur1	Limerick	No Radiocarbon dates
Lough Gur2	Limerick	No Radiocarbon dates
Lough Henney	Down	No Radiocarbon dates
Lough Ine	Cork	No Radiocarbon dates
Lough Kinale (Ballywillin Crannog)	Longford	Hiatus
Lough Lummen	Sligo	Unable to access information
Lough Maumeen	Galway	PDE exceeds threshold
Lough na Trosk	Antrim	PDE exceeds threshold
Lough Nabraddan	Donegal	PDE exceeds threshold
Lough Nadourcon	Donegal	PDE exceeds threshold
Lough Nanallog	Tyrone	No Radiocarbon dates
Lough Neagh	Antrim	Unable to access information
Loughnashade	Armagh	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Magheralagan Lake	Down	No Radiocarbon dates
Maum Townland	Mayo	No Radiocarbon dates
Milleens	Kerry	No Radiocarbon dates
Milmorane	Cork	No Radiocarbon dates
Molly's Lough	Clare	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Moneystown	Wicklow	No Radiocarbon dates
Mongan Bog1	Offaly	Published pollen diagram not to Neolithic
Mooghaun	Clare	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Mount Gabriel	Cork	Elm Decline dificult to distinguish
Mount Shannon	Limerick	No Radiocarbon dates
Moyarwood	Galway	No Radiocarbon dates
Moynagh Lough	Meath	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Muckross Bog	Kerry	No Radiocarbon dates
Munhin Bridge	Mayo	No Radiocarbon dates
Mweenish Bay	Galway	No Radiocarbon dates
Newferry1	Antrim	No Radiocarbon dates
Newlands Cross	Dublin	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Newrath	Kilkenny	Too late for elm decline
Oldtown Kilcashel	Roscommon	No Radiocarbon dates

Ownbegacashel	Mayo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Raheelin	Leitrim	No Radiocarbon dates
Rathdooney	Sligo	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Rathjordan	Limerick	No Radiocarbon dates
Ravansdale Park	Louth	No Radiocarbon dates
Redbog1 (Louth)	Louth	No Radiocarbon dates
Redbog2 (Louth)	Louth	Calibrated date exceeds threshold
Redbog3 (Louth)	Louth	C14 dates after ED, PDE exceeds threshold
Reenadinna Wood	Kerry	Suggested Elm Decline is dated but may represent return to low levels following spike in % values
Reenarea Rise	Kerry	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Rinn na Móna	Clare	No Radiocarbon dates
Roshin Point A	Donegal	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Roundstone I	Galway	No Radiocarbon dates
Roundstone II	Galway	No Radiocarbon dates
Scragh Bog	Westmeath	No Radiocarbon dates
Seaforde Bog	Down	No Radiocarbon dates
Sheheree Bog	Kerry	PDE exceeds threshold
Shower	Tipperary	No Radiocarbon dates
Slieve Gullion	Armagh	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Slievebane	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Slievenahanaghan	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Slievenaslat	Down	PDE exceeds threshold
Soarn's Lough	Antrim	No Radiocarbon dates
Somerset	Derry	No Radiocarbon dates
Spring Bridge	Derry	No Radiocarbon dates
St. John's Wood	Roscommon	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Star Bog	Antrim	No Radiocarbon dates
Tattenamona	Fermanagh	No Radiocarbon dates
The Long Range1	Kerry	No Radiocarbon dates
Tievebulliagh1	Antrim	No Radiocarbon dates
Tievebulliagh2	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Togherbane	Kerry	No Radiocarbon dates
Toome2	Derry	No Radiocarbon dates
Tooreen More West	Cork	No Radiocarbon dates
Treanscrabbagh1	Sligo	No Radiocarbon dates
Treanybrogaun	Mayo	No Radiocarbon dates
Trostan	Antrim	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling

Union Wood Lake	Sligo	Calibrated date exceeds threshold
Whiterath Bog	Louth	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling
Wicklow Mountains I	Wicklow	No Radiocarbon dates
Wicklow Mountains II	Wicklow	No Radiocarbon dates
Woodgrange	Down	No Radiocarbon dates
Woodstown	Waterford	Elm Decline Not Noted/Dated, not enough dates for Bayesian modelling

Bibliography.

Aaby, B. 1986. Trees as anthropogenic indicators in regional pollen diagrams from eastern Denmark. In Behre, K. (ed.) *Anthropogenic indicators in pollen diagrams.* Rotterdam, Balkema, 73 – 93.

Ahlberg, K., Almgren, E., Wright Jr, H. E. & Ito, E. 2001. Holocene stable-isotope stratigraphy at Lough Gur, County Limerick, Western Ireland. *Holocene,* 11, 367 – 372.

Allen, J. R. L. 1996. Windblown trees as a palaeoclimate indicator: the character and role of gusts. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 121, 1 – 12.

Allen, J. R. L. 1998. Windblown trees as a palaeoclimate indicator: regional consistency of a mid-Holocene wind field. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 144, 175 – 181.

Alley, R. B. & Ágústsdóttir, A. M. 2005. The 8k event: cause and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews*, 24(10), 1123 – 1149.

Alley, R. B., Mayewski, P. A., Sowers, T., Stuiver, M., Taylor, K. C. & Clark, P. U. 1997. Holocene climatic instability: A prominent, widespread event 8200 yr ago. *Geology,* 25, 483 – 486.

Almgren, E. 1989. *Woodland establishment, expansion, and regression in association with prehistoric and later human settlements around Lough Gur, Co. Limerick, Ireland.* Unpublished PhD thesis, University of Minnesota.

Almgren, E. 2001. The Sedimentary Record of Woodland Reduction in Association with Prehistoric and Later Settlements around Lough Gur, Co. Limerick, with Special Emphasis on the Neolithic and Bronze Age Periods. *Biology and Environment: Proceedings of the Royal Irish Academy,* 101B, 161 – 162.

Andersen, N. H. 2010. Causewayed enclosures and megalithic monuments as media for shaping Neolithic identities. In Furholt, M., Lüth, F., Müller, J. & Scarre, C. (eds) *Megaliths and Identities, Early Monuments and Neolithic Societies from the Atlantic to the Baltic. Proceeding of the 3rd European Megalithic Studies Group Meeting 13th - 15th of May 2010 at Kiel University, Germany.* Journal of Neolithic Archaeology. 143 – 154.

Andersen, S. T. 1970. The relative pollen productivity and pollen representation of North European trees, and correction factors for tree pollen spectra. *Danmarks geologiske undersøgelse*, B(96).

Andersen, S. T. 1974. Wind Conditions and Pollen Deposition in a Mixed Deciduous Forest. *Grana*, 14, 57 – 63.

Andersen, S. T. 1992. Early- and Middle-Neolithic Agriculture in Denmark: Pollen Spectra from Soils in Burial Mounds of the Funnel Beaker Culture. *Journal of European Archaeology,* 1, 153 – 180.

Anderson, D. 1995. *An abrupt mid-Holocene decline of Pinus sylvestris in Glen Torridon, north west Scotland: implications for palaeoclimatic change.* Oxford, School of Geography, University of Oxford.

Anon 1912. Proceedings - Waterford historical sketch. *Journal of the Royal Society of Antiquaries of Ireland,* 42, 256 – 283.

ApSimon, A. M. 1986. Chronological contexts for Irish megalithic tombs. *Journal of Irish Archaeology,* 3, 5 – 15.

Ashmore, P. 1999. Radiocarbon dating: avoiding errors by avoiding mixed samples. *Antiquity,* 73, 124 – 130.

Atkins, R. 1896. The rude stone monuments of our own and other lands. *Waterford and South East of Ireland Archaeological Journal,* 2, 131 – 161.

Atkinson, M. D. 1992. Betula pendula Roth (B. verrucosa Ehrh.) and B. pubescens Ehrh. *Journal of Ecology*, 80(4), 837 – 870.

Barber, D. C., Dyke, A., Hillaire-Marcel, C., Jennings, A. E., Andrews, J. T., Kerwin, M. W., Bilodeau, G., McNeely, R., Southon, J., Morehead, M. D. & Gagnon, J. M. 1999. Forcing of the cold event of 8,200 years ago by catastrophic drainage of Laurentide lakes. *Nature,* 400, 344 – 348.

Barnosky, C. W. 1988. A Late-Glacial and Post-Glacial pollen record from the Dingle Peninsula, County Kerry. *Proceedings of the Royal Irish Academy Section B-Biological Geological and Chemical Science,* 88, 2 – 37.

Bayes, T. R. 1763. An essay towards solving a problem in the doctrine of chance. *Philosophical Transactions of the Royal Society,* 53, 370 – 418.

Bayliss, A. 2007. Bayesian building: an introduction for the numerically challenged. *Vernacular Architecture,* 38, 75 – 86.

Bayliss, A., Bronk Ramsey, C., van der Plicht, J. & Whittle, A. 2007. Bradshaw and Bayes: Towards a Timetable for the Neolithic. *Cambridge Archaeological Journal,* 17, 1 – 28.

Bayliss, A. & O'Sullivan, A. 2013. Interpreting chronologies for the Mound of the Hostages, Tara and its contemporary contexts in Neolithic and Bronze Age Ireland. In: O'Sullivan, M., Scarre, C. & Doyle, M. (eds.) *Tara-From the past to the future, towards a new research agenda.* Dublin, Wordwell, 26 – 104.

Bayliss, A., van der Plicht, J., Bronk Ramsey, C., McCormac, G., Healy, F. & Whittle, A. 2011. Towards generational time-scales; the quantitative interpretation of archaeological chronologies. In: Whittle, A., Healy, F. & Bayliss, A. (eds.) *Gathering Time: Dating the Early Neolithic enclosures of southern Britain and Ireland.* Oxford, Oxbow, 17 – 59.

Bayliss, A. & Woodman, P. 2009. A New Bayesian Chronology for Mesolithic Occupation at Mount Sandel, Northern Ireland. *Proceedings of the Prehistoric Society,* 75, 101 – 123.

Becker, K., Gearey, B., Eogan, J., McClatchie, M., Nagle, C. & Armit, I. 2016. Seeing beyond the site-an innovative approach to examining later prehistoric Ireland. In Stanley, M. (ed.) *Above and below; the archaeology of roads and light rail.* Dublin, Transport Infrastructure Ireland (TII), 13 – 20.

Behre, K. E. 1981. The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores,* 23, 225 – 245.

Behre, K. E. 1986. *Anthropogenic indicators in pollen diagrams,* Rotterdam, AA Balkema.

Behre, K. E. 2007. Evidence for Mesolithic agriculture in and around central Europe? *Vegetation History and Archaeobotany,* 16, 203 – 219.

Bennett, K., Whittington, G. & Edwards, K. 1994. Recent plant nomenclature changes and pollen morphology in the British Isles. *Quaternary Newsletter,* 73, 1 – 6.

Bennett, K. D. 1984. The post-glacial history of Pinus sylvestris in the British Isles. *Quaternary Science Reviews,* 3, 133 – 155.

Bennett, K. D. 1994. Confidence intervals for age estimates and deposition times in late-Quaternary sediment sequences. *Holocene,* 4, 337 – 348.

Bennett, K. D. & Birks, H. J. B. 1990. Postglacial history of alder (Alnus glutinosa (L.) Gaertn.) in the British Isles. *Journal of Quaternary Science,* 5, 123 – 133.

Bergh, S. & Hensey, R. 2013. Unpicking the Chronology of Carrowmore. *Oxford Journal of Archaeology,* 32, 343 – 366.

Bermingham, N., Coyne, F., Hull, G. & Taylor, K. 2013. *River Road: The archaeology of the Limerick southern ring road. NRA Scheme Monographs 14,* Dublin, The National Roads Authority.

Beug, H. J. 2004. *Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete,* München, Pfeil.

Birks, H. H. 1975. Studies in vegetational history of Scotland IV. Pine stumps in Scottish blanket peats. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences,* 270, 181 – 226.

Birks, H. J. B. 1989. Holocene isochrone maps and patterns of tree-spreading in the British Isles. *Journal of Biogeography,* 16, 503 – 540.

Blaauw, M., Christen, J. A., Bennett, K. D. & Reimer, P. J. 2018. Double the dates and go for Bayes — Impacts of model choice, dating density and quality on chronologies. *Quaternary Science Reviews,* 188, 58 – 66.

Blackburn, P., A. Petty, J. & F. Miller, K. 1988. An Assessment of the Static and Dynamic Factors Involved in Windthrow. *Forestry,* 61(1), 29 – 43.

Blackett, W. R. 1851. Antiquities in the County of Waterford. *Journal of the Royal Society of Antiquaries of Ireland,* 1, 496 – 500.

Blackford, J. J., Edwards, K. J., Dugmore, A. J., Cook, G. T. & Buckland, P. C. 1992. Icelandic volcanic ash and the mid-Holocene Scots pine (Pinus sylvestris) pollen decline in northern Scotland. *Holocene,* 2, 260 – 265.

Blockley, S. P. E., Blaauw, M., Bronk Ramsey, C. & van der Plicht, J. 2007. Building and testing age models for radiocarbon dates in Late-Glacial and Early Holocene sediments. *Quaternary Science Reviews,* 26, 1915 – 1926.

Blockley, S. P. E., Ramsey, C. B., Lane, C. S. & Lotter, A. F. 2008. Improved age modelling approaches as exemplified by the revised chronology for the Central European varved lake Soppensee. *Quaternary Science Reviews,* 27, 61 – 71.

Bogaard, A., Heaton, T. H. E., Poulton, P. & Merbach, I. 2007. The impact of manuring on nitrogen isotope ratios in cereals: archaeological implications for reconstruction of diet and crop management practices. *Journal of Archaeological Science,* 34, 335 – 343.

Bollongino, R. & Burger, J. 2007. Neolithic cattle domestication as seen from ancient DNA. In: Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* London, Oxford University Press for The British Academy, 165 – 187.

Boreux, J. J., Pesti, G., Duckstein, L. & Nacolas, J. 1997. Age model estimation in paleoclimatic research: fuzzy regression and radiocarbon uncertainties. *Palaeogeography, Palaeoclimatology & Palaeoecology,* 128, 29 – 37.

Borlase, W. C. 1897. *The dolmens of Ireland,* London, Chapman and Hall.

Bower, N., Hegerty, L., Lugowski, S. & Miciak, M. 2011. Archaeological excavation report: Caherdrinny 3, County Cork. (E2422). Unpublished excavation report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Bradley, J. 1999. Excavations at Moynagh Lough, Co. Meath. 1997 – 98. *Ríocht na Midhe,* 10, 1 – 17.

Bradley, R. 2007. *The Prehistory of Britain and Ireland,* Cambridge, Cambridge University Press.

Bradley, R. 2008. The end of the beginning: changing configurations in the British and Irish Neolithic. In: Fokkens, H., Coles, B., Van Gijn, A., Kleijne, J., Ponjee, H. & Slappendel, C. (eds.) *Between Foraging and Farming.* Leiden University, Analecta Prehistorica Leidensia, 43 – 49.

Bradshaw, R. H. W. & Browne, P. 1987. Changing Patterns in the Post-Glacial Distribution of Pinus sylvestris in Ireland. *Journal of Biogeography,* 14, 237 – 248.

Bradshaw, R. W. 1988. Spatially-precise studies of forest dynamics. In Huntley, B. & Webb, T. (eds.) *Vegetation history.* The Netherlands, Springer, 725 – 751.

Bridge, M. C., Haggart, B. A. & Lowe, J. J. 1990. The History and Palaeoclimatic Significance of Subfossil Remains of Pinus Sylvestris in Blanket Peats from Scotland. *Journal of Ecology,* 78, 77 – 99.

Brindley, A. 2011. Neolithic Ceramics. In: Mallory, J., Nelis, E. & Hartwell, B. (eds.) *Excavations on Donegore Hill, Co. Antrim.* Dublin, Wordwell, 93 – 130.

Brindley, A. & Lanting, J. N. 1992. Radiocarbon dates from the cemetery at Poulawack, County Clare. *The Journal of Irish Archaeology,* 6, 13 – 17.

Brindley, A., Lanting, J. N. & van der Plicht, J. 2005. Radiocarbon-dated samples from the Mound of the Hostages. In: O'Sullivan, M. (ed.) *Duma na nGiall-The Mound of the Hostages, Tara.* Dublin, Wordwell and University College Dublin, 281 – 296.

Brindley, A. L. & Lanting, J. N. 1989. Radiocarbon Dates for Neolithic Single Burials. *The Journal of Irish Archaeology,* 5, 1 – 7.

Britnell, W. & Savory, H. 1984. *Gwernvale and Penywyrlod: two Neolithic long cairns in the Black Mountains of Brecknock,* Cardiff, The Cambrian Archaeological Association.

Brock, F., Lee, S., Housley, R. A. & Bronk Ramsey, C. 2011. Variation in the radiocarbon age of different fractions of peat: A case study from Ahrenshöft, northern Germany. *Quaternary Geochronology,* 6, 550 – 555.

Bronk Ramsey, C. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon,* 37, 425 – 430.

Bronk Ramsey, C. 1998. Probability and dating. *Radiocarbon,* 40, 461 – 474.

Bronk Ramsey, C. 2000. Comment on 'The Use of Bayesian Statistics for 14C dates of chronologically ordered samples: a critical analysis'. *Radiocarbon,* 42, 199 – 202.

Bronk Ramsey, C. 2001. Development of the radiocarbon calibration program. *Radiocarbon,* 43, 355 – 363.

Bronk Ramsey, C. 2008. Deposition models for chronological records. *Quaternary Science Reviews,* 27, 42 – 60.

Bronk Ramsey, C. 2009a. Bayesian analysis of radiocarbon dates. *Radiocarbon,* 51(1), 337 – 360.

Bronk Ramsey, C. 2009b. Dealing with Outliers and Offsets in Radiocarbon Dating. *Radiocarbon,* 51, 1023 – 1045.

Bronk Ramsey, C. & Lee, S. 2013. Recent and Planned Developments of the Program OxCal. *Radiocarbon,* 55, 720 – 730.

Brown, A. 2007. Dating the onset of cereal cultivation in Britain and Ireland: the evidence from charred cereal grains. *Antiquity,* 81, 1042 – 1052.

Brown, A. G., Hatton, J., O'Brien, C. E., Selby, K. A., Langdon, P. G., Stuijts, I. & Caseldine, C. J. 2005. Vegetation, landscape and human activity in Midland Ireland: mire and lake records from the Lough Kinale-Derragh Lough area, Central Ireland. *Vegetation History and Archaeobotany,* 14, 81 – 98.

Brown, T. 1997. Clearances and Clearings: Deforestation in Mesolithic/Neolithic Britain. *Oxford Journal of Archaeology,* 16, 133 – 146.

Bryant, R. H. 1974. A Late-Midlandian Section at Finglas River, near Waterville, Kerry. *Proceedings of the Royal Irish Academy,* 74B, 161 – 178.

Buck, C. E., Litton, C. D. & Smith, A. F. M. 1992. Calibration of radiocarbon results related to archaeological events. *Journal of Archaeological Science,* 19, 497 – 512.

Bunting, M. J., Armitage, R., Binney, H. A. & Waller, M. 2005. Estimates of 'relative pollen productivity' and 'relevant source area of pollen' for major tree taxa in two Norfolk (UK) woodlands. *Holocene,* 15, 459 – 465.

Burenhult, G. 2001. *The Illustrated guide to the Megalithic Tradition at Carrowmore, Co. Sligo, Ireland,* Tjörnarp, G. Burenhult (self published).

Butler, C. 2005. *Prehistoric Lithics,* Stroud, History Press.

Buzer, J. S. 1980. Pollen analyses of sediments from Lough Ine and Ballyally Lough, Co. Cork, S.W. Ireland. *New Phytologist,* 86, 93 – 108.

Bye, R. A. 1981. Quelites-ethnoecology of edible greens-past, present and future. *Journal of Ethnobiology,* 1, 109 – 123.

Cahill, M. & Brindley, A. 2011. 2.1 Lisduggan North, Co Cork. In Cahill, M. & Sikora, M. (eds.) *Breaking ground, finding graves - reports on the excavations of burials by the National Museum of Ireland, 1927 – 2006.* Dublin, Wordwell in association with the National Museum of Ireland, 12 – 17.

Carlin, N. & Cooney, G. 2017. Transforming our understanding of Neolithic and Chalcolithic society (4000–2200 cal BC) in Ireland. In Stanley, M., Swan, R. &

O'Sullivan, A. (eds.) *Stories of Ireland's Past. TII Heritage 5.* Dublin, Transport Infrastructure Ireland, 23 – 56.

Case, H. 1961. Irish Neolithic Pottery: Distribution and Sequence. *Proceedings of the Prehistoric Society,* 27(9), 174 – 233.

Case, H. 1969. Settlement patterns in the North Irish Neolithic. *Ulster Journal of Archaeology,* 32, 3 – 27.

Caseldine, C. & Fyfe, R. 2006. A modelling approach to locating and characterising elm decline/landnam landscapes. *Quaternary Science Reviews,* 25, 632 – 644.

Caseldine, C. & Hatton, J. 1996. Early Land Clearance and Wooden Trackway Construction in the Third and Fourth Millennia BC at Corlea, Co. Longford. *Biology and Environment: Proceedings of the Royal Irish Academy,* 96B, 11 – 19.

Cassen, S. 2009. *Autour de la Table: exploations archéologiques et discours savants sur des architectures néolithiques à Locmariaquer, Morbihan (Table des Marchands et Grand Menhir),* Nantes, Laboratoire de recherches archeologiques, CNRS & Universitaires de Nantes.

Cassen, S., Audren, C., Hinguan, S., Lannuzel, G. & Marchand, G. 1998. L'habitat Villeneuve-Saint-Germain du Haut-Mée (Saint-Étienne-en-Coglès, Ille-et-Vilaine). *Bulletin de la Société préhistorique française,* 95, 41 – 75.

Caulfield, S. 1978. Neolithic fields, the Irish evidence. In Bowen, H. C. & Fowler, P. J. (eds.) *Early land allotments in the British Isles.* Oxford, British Archaeological Reports, 137 – 143.

Caulfield, S. 1988. *Céide Fields and Ballinderrig Guide,* Morrigan, Killala.

Chapple, R. M. 2018. Catalogue of Radiocarbon Determinations & Dendrochronology Dates (March 2018 release). Belfast, Oculus Obscura Press. Available at https://sites.google.com/site/chapplearchaeology/irish-radiocarbon-dendrochronological-dates

Childe, V. G. 1925. *The dawn of European civilisation,* London, Kegan Paul.

Chique, C., Molloy, K. & Potito, A. 2017. Mid-Late Holocene Vegetational History and Land-Use Dynamics in County Monaghan, North-eastern Ireland—The Palynological Record of Lough Muckno. *Journal of the North Atlantic,* 32, 1 – 24.

Clarke, L. 2012. N22 Tralee Bypass/Tralee to Bealagrellagh, Co. Kerry. Archaeological Services Contract, Stage (iii)-Final Excavation Report for Manor East 1 in the townland of Manor East, Co. Kerry (E4323). Unpublished excavation report. Rubicon Heritage Services Ltd on behalf of Kerry County Council and the National Roads Authority.

Cleary, K. 2015. *Archaeological Networks; Excavations on six gas pipelines in County Cork,* Cork, The Collins Press.

Cleary, R. M. 1993. The Later Bronze Age at Lough Gur: filling in the blanks. In Shee Twohig, E. & Ronayne, M. (eds.) *Past Perceptions. The Prehistoric Archaeology of South-west Ireland.* Cork, Cork University Press, 114 – 120.

Cleary, R. M. 1995. Late Bronze Age settlement and prehistoric burials, Lough Gur, Co. Limerick. *Proceedings of the Royal Irish Academy,* 95C, 1 – 92.

Cleary, R. M. 2000. The potter's craft in prehistoric Ireland with specific reference to Lough Gur, Co. Limerick. In Desmond, A., Johnson, G., McCarthy, M., Sheehan, J. & Shee Twohig, E. (eds.) *New Agendas in Irish Prehistory: Papers in Commemoration of Liz Anderson.* Bray, Wordwell, 119 – 134.

Cleary, R. M. 2003. Enclosed Late Bronze Age Habitation Site and Boundary Wall at Lough Gur, Co. Limerick. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 103C, 97 – 189.

Cleary, R. M. 2018. *The Archaeology of Lough Gur,* Bray, Wordwell.

Clough, T. & Cummins, W. 1988. *Stone axe studies: volume two,* London, Council for British Archaeology.

Cole, E. E. & Mitchell, F. J. G. 2003. Human impact on the Irish landscape during the late Holocene inferred from palynological studies at three peatland sites. *Holocene,* 13, 507 – 515.

Connolly, A. 1999. *The Palaeoecology of Clara Bog, County Offaly.* Unpublished PhD thesis, Trinity College, Dublin.

Connolly, J. 2009. *Derived Irish Peat Map version 2* [Online]. Associated datasets and digital information objects connected to this resource are available at: Secure Archive for Environmental Research Data (SAFER) managed by Environmental Protection Agency Ireland. Available:http://erc.epa.ie/safer/resource?id=4b9efdbe-7f4e-102d-b891-8d8f2407b579 [Accessed 09/02/16].

Connolly, M. 2008. *The Prehistoric Settlement of the Lee Valley, Tralee, Co. Kerry: A Landscape Perspective.* Unpublished PhD thesis, University College Cork.

Connolly, M. 2015. *2015:062 - Killaclohane, Kerry* [Online]. Bray, Wordwell. Available: http://www.excavations.ie/report/2015/Kerry/0024117/ [Accessed 03/11/2017].

Cook, G. T., Dugmore, A. J. & Shore, J. S. 1998. The influence of pre-treatment on humic acid yield and 14C age of Carex peat. *Radiocarbon,* 40, 21 – 27.

Cooney, G. 1983. A boom in Neolithic houses. *Archaeology Ireland,* 13, 13 – 16.

Cooney, G. 2000. *Landscapes of Neolithic Ireland,* London, Routledge.

Cooney, G. 2007. Parallel worlds or multi-stranded identities? Considering the process of 'going over' in Ireland and the Irish Sea zone. In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* Oxford, Oxford University Press for the British Academy, 543 – 566.

Cooney, G., Bayliss, A., Healy, F., Whittle, A., Danaher, E., Cagney, L., Mallory, J., Smyth, J., Kador, T. & O'Sullivan, M. 2011. Ireland. In Whittle, A., Healy, F. & Bayliss, A. (eds.) *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland.* Oxford, Oxbow, 562 – 669.

Cooney, G. & Grogan, E. 1999. *Irish prehistory: a social perspective,* Dublin, Wordwell.

Coxon, P. 1983. A peat profile at Imlagh, Valencia Island. In Coxon, P., Mitchell, G. F. and Price, A. (eds). *Northwest Iveragh Co Kerry, Field guide No. 6.* Dublin, Irish Association for Quaternary Research, 14 – 18.

Coxon, P. 1985. Botanical appendix. In Mitchel, F. (ed.) *Landscape Archaeology in South-west Valentia Island: A Field Guide.* Dublin, F. Mitchell (self published).

Coxon, P. & Browne, P. 1991. The Nephin Beg Range and the late-glacial. In Coxon, P. (ed.) *North Mayo. Fieldguide No. 14.* Dublin, Irish Association for Quaternary Studies, 41 – 49.

Coxon, P. & Flegg, A. 1985. A Middle Pleistocene Interglacial Deposit from Ballyline, Co. Kilkenny. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 85B, 107 – 120.

Craig, A. J. 1978. Pollen Percentage and Influx Analyses in South-East Ireland: A Contribution to the Ecological History of the Late-Glacial Period. *Journal of Ecology,* 66, 297 – 324.

Crombé, P. & Vanmortfort, B. 2007. The Neolithisation of the Scheldt basin in western Belgium. In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* London, Oxford University Press for The British Academy, 263 – 285.

Crushell, P., Connolly, A., Schouten, M. & Mitchell, F. J. G. 2008. The changing landscape of Clara Bog: the history of an Irish raised bog. *Irish Geography,* 41, 89 – 111.

Cummings, V. 2017. *The Neolithic of Britain and Ireland,* London, Routledge.

Cummings, V. & Harris, O. 2011. Animals, people and places: the continuity of hunting and gathering practices across the Mesolithic-Neolithic transition in Britain. *European Journal of Archaeology,* 14(3), 361 – 393.

Cummings, V. & Whittle, A. 2003. Tombs with a view: landscape, monuments and trees. *Antiquity,* 77, 255 – 266.

Cunningham, D. A., Farrell, E. P. & Collins, J. F. 1999. Soil responses to land-use change - a study in south-west Ireland. *Forest Ecology and Management,* 119, 63 – 76.

Danaher, E. 2003. A final report on the archaeological excavation of an Early Neolithic house and three Bronze Age pits at Barnagore, Ballincollig, Co. Cork. (02E0384). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

Danaher, E. 2007. *Monumental Beginnings. The Archaeology of the N4 Sligo Inner Relief Road. National Roads Authority Monograph 1,* Dublin, The National Roads Authority.

Danaher, E. 2009. An early Neolithic House at Barnagore, Co. Cork. *Journal of Irish Archaeology,* 18, 1 – 16.

Danaher, E. 2013a. Barnagore 3- Early Neolithic House. *Generations: the archaeology of five national road schemes in County Cork. NRA Scheme Monographs 13.* Dublin, The National Roads Authority, 43 – 46.

Danaher, E. 2013b. Curraheen 1- settlement: conjoined enclosures. In Hanley, K. & Hurley, M. F. (eds.) *Generations: the archaeology of five national road schemes in*

County Cork. NRA Scheme Monographs 13. Dublin, The National Roads Authority, 215 – 222.

Danaher, E. & Cagney, L. 2004a. Final report on the archaeological excavation of an Early Medieval ringfort and prehistoric settlement evidence at Curraheen 1, Ballincollig, Co. Cork. (01E1209). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

Danaher, E. & Cagney, L. 2004b. Report on the archaeological excavation of a multi-phased site at Ballinaspig More 5, Ballincollig, Co. Cork. (02E1033). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

Danaher, E. & Cagney, L. 2004c. Report on the archaeological excavation of Early Neolithic & post Medieval features at Ballinaspig More 4, Ballincollig, Co. Cork. (02E0947). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

David, A. & Walker, E. A. 2004. Wales during the Mesolithic period. In Saville, A. (ed.) *Mesolithic Scotland and its neighbours: The Early Holocene Prehistory of Scotland, its British and Irish Context and some Northern European Perspectives.* Edinburgh, Society of Antiquaries of Scotland, 299 – 337.

Davies, P., Robb, J. G. & Ladbrook, D. 2005. Woodland clearance in the Mesolithic: the social aspects. *Antiquity,* 79, 280 – 288.

De Valera, R. & Ó Nualláin, S. 1961. *Survey of the Megalithic Tombs of Ireland. Vol. I, Co. Clare,* Dublin, The Stationary Office.

De Valera, R. & Ó Nualláin, S. 1982. *Survey of the megalithic tombs of Ireland. Volume IV,* Dublin, The Stationery Office.

Demnick, D., Diers, S., Bork, H.-R., Fritsch, B., Müller, J., Beyer, A., Brozio, J.-P., Erkul, E., Kroll, H. & Tafel, E. 2008. Der Großdolmen Lüdelsen 3 in der westlichen Altmark (Sachsen-Anhalt) – Baugeschichte, Rituale und Landschaftsrekonstruktion**.** *Journal of Neolithic Archaeology*. 10. Available at: <http://www.jna.uni-kiel.de/index.php/jna/article/view/28>. [Accessed 04/10/18].

Denslow, J. S., Ellison, A. M. & Sanford, R. E. 1998. Treefall Gap Size Effects on above- and below-Ground Processes in a Tropical Wet Forest. *Journal of Ecology,* 86, 597 – 609.

Dodson, J. R. 1990. The Holocene Vegetation of a Prehistorically Inhabited Valley, Dingle Peninsula, Co. Kerry. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 90B, 151 – 174.

Doody, M. 1995. The Claidh Dubh. Interim report. In Eogan, G. (ed.) *Discovery Programme reports: 2. Project results 1993.* Dublin, Royal Irish Academy, 12 – 18.

Doody, M. 2008. The Claidh Dubh - survey and excavation. In Doody, M. (ed.) *The Ballyhoura Hills Project. Discovery Programme Monograph 7.* Bray, Wordwell, 559 – 569.

Douda, J., Doudova, J., Drasnarova, A., Kunes, P., Hadincova, V., Krak, K., Zakravsky, P. & Mandak, B. 2014. Migration patterns of subgenus Alnus in Europe since the last glacial maximum: a systematic review. *PLoS One,* 9. Available:https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0088709

Dowd, M. 2002. Kilgreany, Co. Waterford: biography of a cave. *Journal of Irish Archaeology,* 11, 77 – 97.

Dowd, M. 2008. The use of caves for funerary and ritual practices in Neolithic Ireland. *Antiquity*, 305 – 317.

Drum, M. 2007. Archaeological Excavation Report 05E1391 - Kilsheelan, Co. Tipperary. Unpublished excavation report, Eachtra Archaeological Projects on behalf of Jeremiah, Patrick and Mauri Harrington of Binchy & Co.

Du Noyer, G. V. 1866. On cromleacs near Tramore in the County of Waterford; with remarks on the classification of ancient Irish earthen and megalithic structures. *Journal of the Royal Society of Antiquaries of Ireland,* 8, 474 – 482.

Dugmore, A. J., Cook, G. T., Shore, J. S., Newton, A. J., Edwards, K. J. & Larsen, G. 1995. Radiocarbon dating tephra layers in Britain and Iceland. *Radiocarbon,* 37, 379 – 388.

Dunne, L. 2002. *Manor West, Co. Kerry* [Online]. Bray: Wordwell. Available: https://www.excavations.ie/report/2000/Kerry/0005279/ [Accessed 14/02/18].

Dunne, L. 2005. Recent Archaeological Excavations in the Tralee Area. *In* Connolly, M. (ed.) *Past Kingdoms: Recent Archaeological Research, Surveys and Excavations in Co. Kerry.* Proceedings of the 2005 Archaeological Lecture Series, The Heritage Council, 40 – 64.

Dunne, L. 2017. Archaeological impact Assessment Report, Proposed Dredging Operations, Dingle, Co. Kerry. Unpublished report. Laurence Dunne Archaeology on behalf of Richard Church, Nicholas O'Dwyer & Associates.

Dunne, L. & Buckley, K. 2006. Interim Archaeological Monitoring and Excavation Report, Gortonora, Dingle, Co. Kerry. (06E1111). Unpublished excavation report. Eachtra Archaeological Projects.

Dwyer, R. B. & Mitchell, F. J. G. 1997. Investigation of the environmental impact of remote volcanic activity on north Mayo, Ireland, during the mid-Holocene. *Holocene,* 7, 113 – 118.

Edmonds, M. 1995. *Stone tools and society,* London, Routledge.

Edmonds, M. 1998. *Ancestral geographies in the Neolithic,* London, Routledge.

Edwards, K. J. 1981. The separation of *Corylus* and *Myrica* pollen in modern and fossil samples. *Pollen et Spores,* 23, 205 – 218.

Edwards, K. J. 1989. Meso-Neolithic vegetational impacts in Scotland and beyond: palynological considerations. In Bonsall, C. (ed.) *The Mesolithic in Europe.* Edinburgh, John Donald, 143 – 155.

Edwards, K. J. & Hirons, K. R. 1984. Cereal pollen grains in pre-elm decline deposits: Implications for the earliest agriculture in Britain and Ireland. *Journal of Archaeological Science,* 11, 71 – 80.

Edwards, R. & Brooks, A. 2008. The island of Ireland: Drowning the myth of an Irish land-bridge? *The Irish Naturalists' Journal. Special. Supplement: Mind the Gap: Postglacial colonization of Ireland,* 29, 19 – 34.

Edwards, K. & Whittington, G. 2000. Multiple charcoal profiles in a Scottish lake: Taphonomy, fire ecology, human impact and inference. *Palaeogeography, Palaeoclimatology & Palaeoecology,* 164, 67 – 86.

Ellison, C. R. W., Chapman, M. R. & Hall, I. R. 2006. Surface and Deep Ocean Interactions During the Cold Climate Event 8200 Years Ago. *Science,* 312, 1929 – 1932.

Eogan, G. & Grogan, E. 1991. Prehistoric and Early Historic Culture Change at Brugh na Bóinne. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 91C, 105 – 132.

Erdtman, K. J. 1928. Studies in the post-artic history of the forests of north-western Europe. *Geologiska Föreningens i Stockholm Förhandlingar,* 50, 123 – 192.

Faegri, K., Iversen, J., Kaland, P. & Krywinski, K. 1989. *Textbook of pollen analysis,* Chichester, Wiley.

Farrell, A. & Coxon, P. 2004. N25 Waterford By-pass: Sedimentological and Palaeoenvironmental Investigation of Wetland Area adjacent to Woodstown. Unpublished report: The National Roads Authority.

Farrelly, J. 2012. *TS082-104----, Marlfield* [Online]. archaeology.ie. Available: http://webgis.archaeology.ie/historicenvironment/ [Accessed 14/02/18].

Fischer, A. 2003. Trapping up the rivers and trading across the sea: steps towards the Neolithisation of Denmark. In Kingdgren, L., Knutsson, H., Loeffler, K., Larsson, D. & Akerlund, A. (eds.) *Mesolithic on the move: Papers presented on the sixth international conference on the Mesolithic in Europe, Stockholm 2000.* Oxford, Oxbow Book, 405 – 413.

FitzGerald, M. 2007. Catch of the day at Clowanstown, Co. Meath. *Archaeology Ireland,* 21(4), 12 – 15.

Fossitt, J. 1994. Late-glacial and Holocene vegetational history of western Donegal, Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy,* 94B, 1 – 31.

Fossitt, J. A. 2000. *A guide to habitats in Ireland,* Kilkenny, The Heritage Council.

Fraser, R. A., Bogaard, A., Heaton, T., Charles, M., Jones, G., Christensen, B. T., Halstead, P., Merbach, I., Poulton, P. R., Sparkes, D. & Styring, A. K. 2011. Manuring and stable nitrogen isotope ratios in cereals and pulses: towards a new archaeobotanical approach to the inference of land use and dietary practices. *Journal of Archaeological Science,* 38, 2790 – 2804.

Frazer, F. C. & King, J. E. 1954. Faunal remains. In Clarke, J. G. D. (ed.) *Excavations at Starr Carr* Cambridge, Cambridge University Press, 70 – 95.

Fredengren, C. 2002. *Crannogs,* Bray, Wordwell.

Fredengren, C. 2009. Lake platforms at Lough Kinale - memory, reach and place: A Discovery programme project in the Irish midlands. In McCartan, S., Schulting, R., Warren, G. & Woodman, P. C. (eds.) *Mesolithic horizons.* Oxford, Oxbow Books, 882 – 886.

Gaillard, M.-J., Sugita, S., Bunting, M. J., Middleton, R., Broström, A., Caseldine, C., Giesecke, T., Hellman, S. E. V., Hicks, S., Hjelle, K., Langdon, C., Nielsen, A.-B., Poska, A., von Stedingk, H., Veski, S. & members, P. 2008. The use of modelling and simulation approach in reconstructing past landscapes from fossil pollen data: a review and results from the POLLANDCAL network. *Vegetation History and Archaeobotany,* 17, 419 – 443.

Garrow, D. & Sturt, F. 2011. Grey waters bright with Neolithic Argonauts? Maritime connections and the Mesolithic-Neolithic transition within the 'western seaways' of Britain, *c.* 5000 – 3500 BC. *Antiquity,* 85, 59 – 72.

Gauch, H. G., Whittaker, R. H. & Wentworth, T. R. 1977. A Comparative Study of Reciprocal Averaging and Other Ordination Techniques. *Journal of Ecology,* 65, 157 – 174.

Gear, A. J. & Huntley, B. 1991. Rapid changes in the range limits of scots pine 4000 years ago. *Science,* 251, 544 – 547.

Gearey, B., Hopla, E. J. & Marshall, P. 2010. Palynological Analyses of Deposits from Clowanstown I, Kilmainham 1c and Lismullin I: M3 Clonee to North of Kells Motorway Scheme. Final report volume 2: Appendices. Unpublished report, Birmingham Archaeo-Environmental on behalf of Archaeology Consultancy Services Ltd. for Meath County Council and the National Roads Authority.

Gearey, B. R., Marshall, P. & Hamilton, D. 2009. Correlating archaeological and palaeoenvironmental records using a Bayesian approach: a case study from Sutton Common, South Yorkshire, England. *Journal of Archaeological Science,* 36, 1477 – 1487.

Gendel, P. 1984. *Mesolithic Social Territories in North-western Europe,* Oxford, British Archaeological Reports S218.

Ghilardi, B. 2012. *Farming and woodland dynamics in north Sligo during the Holocene based on lake-sediment investigations.* Unpublished PhD thesis, National University of Ireland, Galway.

Ghilardi, B. & O'Connell, M. 2012. Early Holocene vegetation and climate dynamics with particular reference to the 8.2 ka event: pollen and macrofossil evidence from a small lake in western Ireland. *Vegetation History and Archaeobotany,* 22, 99 – 114.

Ghilardi, B. & O'Connell, M. 2013. Fine-resolution pollen-analytical study of Holocene woodland dynamics and land use in north Sligo, Ireland. *Boreas,* 42, 623 – 649.

Giesecke, T., Bjune, A. E., Chiverrell, R. C., Seppä, H., Ojala, A. E. K. & Birks, H. J. B. 2008. Exploring Holocene continentality changes in Fennoscandia using present and past tree distributions. *Quaternary Science Reviews,* 27, 1296 – 1308.

Gillespie, R. 1989. Fundamentals of bone degradation chemistry: collagen is not 'the way'. *Radiocarbon,* 32, 239 – 246.

Girling, M. A. 1988. The bark beetle Scolytus scolytus (fabricius) and the possible role of elm disease in the early Neolithic. In Jones, M. (ed.) *Archaeology and the flora of the British Isles.* Oqford, Oxford University Committee for Archaeology Monograph Number 14, 34 – 38.

Girling, M. A. & Greig, J. 1985. A first fossil record for Scolytus scolytus (F.) (elm bark beetle): its occurrence in elm decline deposits from London and the implications for Neolithic elm disease. *Journal of Archaeological Science,* 12, 347 – 351.

Gleeson, C. & Breen, G. 2006a. Final Report on archaeological investigations at Sites 1 and 2, in the townland of Granny, Co. Kilkenny. 04E0226. Unpublished excavation report. Headland Archaeology Ltd on behalf of Kilkenny County Council and the National Roads Authority.

Gleeson, C. & Breen, G. 2006b. Final Report on archaeological investigations at Sites 21-23, in the townland of Granny, Co. Kilkenny. 04E0200. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Godwin, H. 1975. *History of the British flora: A factual basis for phytogeography, 2nd ed.,* Cambridge, Cambridge University Press.

Göransson, H. 1984. Pollen analytical investigations in the Sligo area. In Burenhult, G. (ed.) *The archaeology of Carrowmore.* Stockholm, Institute of Archaeology, University of Stockholm, 154-193.

Göransson, H. 2002. Pollen Analytical Investigations in the Sligo Area. In Timoney, M. (ed.) *A Celebration of Sligo: First Essays for Sligo Field Club.* Sligo, Sligo Field Club, 85 – 95.

Gowen, M. 1988. *Three Irish gas pipelines: new archaeological evidence in Munster,* Bray, Wordwell.

Gowen, M., Ó Néill, J. & Philips, M. 2005. *The Lisheeen Mine Archaeological Project 1996 – 8,* Bray, Wordwell.

Gowen, M. & Tarbett, C. 1988. A third season at Tankardstown. *Archaeology Ireland,* 2, 156.

Gowen, M. & Tarbett, C. 1989. Tankardstown South Neolithic/Bronze Age. In Bennett, I. (ed.) *Excavations 1988: summary account of excavations in Ireland.* Dublin, Wordwell, 24 – 26.

Gowen, M. & Tarbett, C. 1990. Tankardstown South Neolithic house sites. In Bennett, I. (ed.) *Excavations 1989: summary accounts of archaeological excavations in Ireland.* Dublin, Wordwell, 38 – 39.

Graves, J. 1850. Cromleac. *Journal of the Royal Society of Antiquaries of Ireland,* 1, 129 – 131.

Greig, J. 1987. Pollen and plant macrofossils. *In* Smith, C. & Lynch, F. (eds.) *Trefignath and Din Dryfol.* Bangor: The Cambrian Archaeological Association, 39 – 44.

Griffiths, S. & Gearey, B. 2017. The Mesolithic-Neolithic Transition and the chronology of the "Elm Decline" from Yorkshire and Humberside, United Kingdom. *Radiocarbon,* 59, 1321 – 1345.

Grimm 2004. *Tilia and TGView*. Springfield, Illinois, Illinois State Museum.

Grogan, E. 1996. Neolithic houses in Ireland. In Darvill, T. & Thomas, J. (eds.) *Neolithic houses in northwest Europe and beyond. Monograph Series 57.* Oxford, Oxbow.

Grogan, E. 2002. Neolithic houses in Ireland: a broader perspective. *Antiquity,* 76, 517 – 525.

Grogan, E. & Eogan, G. 1987. Lough Gur excavations by Séan P. Ó Ríordáin: further Neolithic and Beaker habitations on Knockadoon. *Proceedings of the Royal Irish Academy,* 87C, 299 – 506.

Grogan, E. & Roche, H. 2007. The prehistoric pottery assemblage for a site at Caherabbey Upper (Site 185:1-4: E2298). N8 Cashel to Mitchelstown Road Scheme. Unpublished excavation report by Margaret Gowen and Co. Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

Grubb, I. 1944. Notes on two prehistoric burial sites in the townland of Seskin, Co. Waterford. *Journal of the Royal Society of Antiquaries of Ireland*, 176 – 179.

Hall, V. A. 1989. The vegetational landscape of mid Co. Down over the last half millennium; the documentary evidence. *Ulster Folklife,* 35, 72 – 85.

Hall, V. A. 1990. Recent landscape history from a Co. Down lake deposit. *New phytologist,* 155, 377 – 383.

Hall, V. A. 1994. Landscape development in northeast Ireland over the last half millennium. *Review of Palaeobotany & Palynology,* 82, 75 – 82.

Hall, V. A. 2003. Vegetation history of mid- to western Ireland in the 2nd millennium AD; fresh evidence from tephra-dated palynological investigations. *Vegetation History and Archaeobotany,* 12, 7 – 17.

Hall, V. A., Pilcher, J. R. & Bowler, M. 1993. Pre-Elm Decline Cereal-Size Pollen: Evaluating Its Recruitment to Fossil Deposits Using Modern Pollen Rain Studies. *Biology and Environment: Proceedings of the Royal Irish Academy,* 93B, 1 – 4.

Hall, V. A., Pilcher, J. R. & McCormac, F. G. 1994. Icelandic volcanic ash and the mid-Holocene Scots pine (Pinus sylvestris) decline in the north of Ireland: no correlation. *Holocene,* 4, 79 – 83.

Hall, V. A., Pilcher, J. R. & McCormac, F. G. 1996. Hekla-4 ash, the pine decline in Northern Ireland and the effective use of tephra isochrones: a reply to Edwards, Dugmore, Buckland, Blackford and Cook. *Holocene,* 6, 496 – 497.

Halwas, S. 2007. Analysis of Carbonized Plant remains for a site at Caherabbey Upper (Site 185.1-4: E2298). N8 Cashel to Mitchelstown Road Scheme. . Unpublished Report by Margaret Gowen & Co. Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

Hamilton, M. & Hedges, R. E. M. 2011. Carbon and nitrogen stable isotope values of animals and humans from causewayed enclosures. In Whittle, A., Healy, F. & Bayliss, A.

(eds.) *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland.* Oxford: Oxbow Books, 36 – 47.

Hammer, Ø., Harper, D. A. T. & Ryan, P. D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica,* 4(1), 1 – 9.

Hanley, K. & Hurley, M. F. 2013. *Generations: the archaeology of five national road schemes in County Cork. NRA Scheme Monographs 13,* Dublin, The National Roads Authority.

Harbison, P. 1992. *Guide to the national and historic monuments of Ireland,* Dublin, Gill and Macmillan Ltd.

Healy, F., Heaton, M., Lobb, S. J., Allen, M. J., Fenwick, I. M., Grace, R. & Scaife, R. G. 1992. Excavations of a Mesolithic Site at Thatcham, Berkshire. *Proceedings of the Prehistoric Society,* 58, 41 – 76.

Healy, M. 1987. *The history of woodland on Muckross Peninsula, Killarney in Lateglacial and Postglacial times.* Unpublished MA thesis, University College, Cork.

Hede, M. U., Rasmussen, P., Noe-Nygaard, N., Clarke, A. L., Vinebrooke, R. D. & Olsen, J. 2010. Multiproxy evidence for terrestrial and aquatic ecosystem responses during the 8.2 ka cold event as recorded at Højby Sø, Denmark. *Quaternary Research,* 73, 485 – 496.

Hedges, R. E. M., Housley, R. A., Law, I. A. & Bronk, C. R. 1990. Radiocarbon dates from the Oxford AMS system: Archeometry Datelist 10. *Archaeometry,* 32, 101 – 108.

Heegaard, E., Birks, H. J. B. & Telford, R. J. 2005. Relationships between calibrated ages and depth in stratigraphical sequences: an estimation procedure by mixed-effect regression. *Holocene,* 15, 612 – 618.

Heery, A. 1997. The vegetation history of two small lakes sites adjacent to eskers in Central Ireland. *Quaternary Newsletter*, 33 – 36.

Hegerty, L. 2010. Archaeological Excavation Report. Neolithic and Beaker Features, Middle Bronze Age Structures and Iron Age Industrial Activity Ballynamona 2 Co Cork. (E2429). Unpublished Excavation Report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Heiri, O., Lotter, A. F. & Lemcke, G. 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. *Journal of Paleolimnology,* 25, 101 – 110.

Hellman, S., Bunting, M. J. & Gaillard, M. J. 2009. Relevant Source Area of Pollen in patchy cultural landscapes and signals of anthropogenic landscape disturbance in the pollen record: A simulation approach. *Review of Palaeobotany and Palynology,* 153, 245 – 258.

Herity, M. 1964. The finds from the Irish portal dolmens. *Journal of the Royal Society of Antiquaries of Ireland,* 94(2), 123 – 144.

Herity, M. 1982. Irish decorated Neolithic pottery. *Proceedings of the Royal Irish Academy* 82C, 248 – 404.

Hill, M. O. 1974. Correspondence Analysis: a neglected multivariate method. *Applied Statistics,* 23, 350 – 354.

Hill, M. O. & Gauch, H. G. 1980. Detrended Correspondence Analysis: An Improved Ordination Technique. *Vegetation,* 42, 47 – 58.

Hirons, K. R. 1983. Percentage and accumulation rate pollen diagrams from east Tyrone. In Reeves-Smyth, T. & Hamond, F. (eds.) *Landscape archaeology in Ireland.* Oxford, British Archaeological Reports, 95 – 117.

Hirons, K. R. 1984. *Palaeoenvironmental investigations in east Co. Tyrone, Northern Ireland.* Unpublished PhD thesis, Queen's University Belfast.

Hirons, K. R. & Edwards, K. J. 1986. Events at and around the first and second *Ulmus* declines: Palaeoecological investigations in Co. Tyrone, Northern Ireland. *New Phytologist,* 104, 131 – 153.

Hirons, K. R. & Thompson, R. 1986. Palaeoenvironmental application of magnetic measurements from inter-drumlin hollow lake sediments near Dungannon, Co. Tyrone, Northern Ireland. *Boreas,* 15, 117 – 135.

Hodder, I. 1982. *Symbols in Action: Ethnoarchaeological Studies of Material Culture,* Cambridge, Cambridge University Press.

Holland, S. M. 1975. *Pollen analytical studies concerning settlements and early ecology in Co. Down N. Ireland.* Unpublished PhD thesis, Queen's University, Belfast.

Horgan, T., Keane, M., McCarthy, R., Lally, M. & Thompson, D. 2003. *A guide to forest tree species selection and silviculture in Ireland,* Dublin, COFORD.

Huang, C. C. 2002. Holocene landscape development and human impact in the Connemara Uplands, Western Ireland. *Journal of Biogeography,* 29, 153 – 165.

Hughes, J. 2006. N25 Waterford bypass, contract 3. Final report on archaeological investigations at sites 24-30 in the townland of Granny, County Kilkenny. 04E0548. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Hughes, J., Wilkins, B. & Price, J. 2011. Newrath 35-Neolithic ritual and Iron Age metalworking. In Eogan, J. & Shee Twohig, E. (eds.) *Cois tSiúire-nine thousand years of human activity in the Lower Suir Valley. Archaeological excavations on the N25 Waterford City Bypass. NRA Scheme Monographs 8.* Dublin, The National Roads Authority, 128 – 135.

Hull, G. 2015. Gas Pipeline to Great Island, Counties Kilkenny and Wexford. Final Archaeological Excavation and Monitoring Report for Bord Gáis Networks. (12E0356). Unpublished excavation report. TVAS Ireland Ltd. on behalf of Bord Gáis Networks.

Huntley, B. 2012. Reconstructing palaeoclimates from biological proxies: Some often overlooked sources of uncertainty. *Quaternary Science Reviews,* 31, 1 – 16.

Huntley, B. & Birks, H. J. B. 1983. *An atlas of past and present pollen maps for Europe: 0–13000 years ago.,* Cambridge, Cambridge University Press.

Hurcombe, L. 2014. *Perishable material culture in prehistory,* London Routledge.

Innes, J. B. & Blackford, J. J. 2003. The Ecology of Late Mesolithic Woodland Disturbances: Model Testing with Fungal Spore Assemblage Data. *Journal of Archaeological Science,* 30, 185 – 194.

Innes, J. B., Blackford, J. J. & Rowley-Conwy, P. 2003. The start of the Mesolithic-Neolithic transition in North-West Europe – the palynological contribution. *Antiquity,* 77(297).

Innes, J. B., Blackford, J. J. & Simmons, I. G. 2004. Testing the integrity of fine spatial resolution palaeoecological records: microcharcoal data from near-duplicate peat profiles from the North York Moors, UK. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 214, 295 – 307.

Iversen, J. 1941. Landnam i Danmarks Stenalder: en pollenanalytisk undersøgelse over det første landbrugs indvirkning paa vegetationsudviklingen (Land occupation in Denmark's stone age: a pollen-analytical study of the influence of farmer culture on the vegetational development). *Danmarks geologiske undersøgelse, II,* 66, 1 – 68.

Jacobi, R. M. 1976. Britain Inside and Outside Mesolithic Europe. *Proceedings of the Prehistoric Society,* 42, 67 – 84.

Jacobson, G. L. & Bradshaw, R. H. W. 1981. The selection of sites for paleovegetational studies. *Quaternary Research,* 16, 80 – 96.

Jennings, E. 1997. *Palaeoecological studies towards the reconstruction of the Holocene history of Pinus sylvestris L. in western Ireland.* Unpublished PhD thesis, National University of Ireland, Galway.

Jessen, K. 1949. Studies in Late Quaternary Deposits and Flora-History of Ireland. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 52, 85 – 290.

Jessen, K., Andersen, S. T. & Farrington, A. 1959. The Interglacial deposit near Gort, Co. Galway, Ireland. *Proceedings of the Royal Irish Academy*, 1 – 77.

Johnston, P. & Tierney, J. 2010. Archaeological excavation report, two Neolithic structures and two Fulachta Fiadh. Ballinglanna North 3, County Cork (E2416). Unpublished excavation report: Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Johnston, P. & Tierney, J. 2011. Archaeological Excavation Report. Prehistoric activity at Ballynamona 1, Co. Cork. E2428. Unpublished excavation report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Jones, C. 2007. *Temples of stone. Exploring the megalithic tombs of Ireland,* Cork, Collins Press.

Kador, T. 2010. The last of the old: a homogenous Later Mesolithic Ireland? In Finlayson, B. & Warren, G. (eds.) *Landscapes in transition.* Oxford, Oxbow Books, 147 – 157

Karlén, W. & Larsson, L. 2007. Chapter 11 - Mid-Holocene climatic and cultural dynamics in Northern Europe. In Anderson, D. G., Maasch, K. A. & Sandweiss, D. H. (eds.) *Climate Change and Cultural Dynamics.* San Diego, Academic Press, 407 – 434

Kent, M. & Coker, P. 1992. *Vegetation Description and Analysis,* London, Belhaven Press.

Kiely, J. 1999. Cloghers, Tralee, Co. Kerry. In Bennett, I. (ed.) *Excavations 1998: 97.* Dublin, Wordwell/Duchas, 97.

Kiely, J. 2003. A Neolithic house at Cloghers, Co. Kerry. In Armit, I., Murphy, E., Nelis, E. & Simpson, D. (eds.) *Neolithic Settlement in Ireland and Western Britain.* Oxford: Oxbow Books, 182 – 187.

Kiely, J. & Dunne, L. 2005. Recent Archaeological Excavations in the Tralee Area. In Connolly, M. (ed.) *Past Kingdoms: Recent Archaeological Research, Survey and Excavation in County Kerry.* Castleisland, Kerry County Council and The Heritage Council, 39 – 64.

Kiely, J. & O'Donoghue, J. 2010. Archaeological Excavation Report Prehistoric Activity, Early Medieval Roundhouses and Iron Working, and Medieval Structures, Gortnahown, Co. Cork. (E2426). Unpublished excavation report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Kimball, M. J. 2006. Common pools and private tools? Mobility and economy during Ireland's Later Mesolithic. *Journal of Anthropological Archaeology,* 25, 239 – 247.

Klimaschewski, A. 2009. Pollen analysis, Rothe House garden, Kilkenny. Unpublished report: School of Geography Archaeology & Palaeoecology, Queen's University Belfast, Belfast.

Kytmannow, T. 2008. *Portal tombs in the landscape : the chronology, morphology and landscape setting of the portal tombs of Ireland, Wales and Cornwall,* Oxford, Archaeopress.

Lageard, J. G. A., Chambers, F. M. & Thomas, P. A. 1999. Climatic significance of the marginalization of Scots pine (Pinus sylvestris L.) *c.*2508 BC at White Moss, south Cheshire, UK. *Holocene,* 9, 321 – 331.

Lamb, H. & Thompson, A. 2005. Unusual mid-Holocene abundance of Ulmus in western Ireland – human impact in the absence of a pathogen? *Holocene,* 15, 447 – 452.

Laporte, L., Joussaume, R. & Scarre, C. 2001. The perception of space and geometry: megalithic monuments of west-central France in their relationship to landscape. In Scarre, C. (ed.) *Monuments and landscape.* London, Routledge, 1 – 16.

Larsson, L. B. 2007. Mistrust traditions, consider innovations? The Mesolithic-Neolithic transition in southern Scandinavia. In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* London, Oxford University Press for The British Academy, 595 – 616.

Lehane, J. & Leigh, D. 2010. Archaeological Excavation Report. Prehistoric site with enclosure, structures, two ring ditches and associated cist burials at Ballynacarriga 3 Co Cork. (E2412). Unpublished Excavation Report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Leira, M., Cole, E. E. & Mitchell, F. J. G. 2007. Long term impacts of atmospheric deposition and peat erosion on an oligotrophic lake in eastern Ireland. *Journal of Paleolimnology,* 38, 49 – 71.

Lennon, A. M. 2007. Preliminary report on archaeological testing of Neolithic house site at Marlfield, Clonmel, Co. Tipperary. Unpublished monitoring report.

Lennon, A. M. 2009. N25 Waterford bypass alternative route. Archaeological investigation. Contract 1. Final report on the archaeological excavation of Bawnfune 2, County Waterford. E3446. Unpublished Excavation Report. Archaeological Consultancy Services Ltd. on behalf of Waterford County Council and the National Roads Authority.

Lennon, A. M. 2010. Bawnfune 2. Prehistoric settlement activity. In Bennett, I. (ed.) *Excavations 2007: summary accounts of excavations in Ireland, No. 1802.* Dublin, Wordwell, 511.

Lennon, A. M., O'Hara, R. & Ginn, V. 2011. Bawnfune 2, Co. Waterford. In Eogan, J. & Shee Twohig, E. (eds.) *Cois tSiúire – nine thousand years of human activity in the lower Suir valley. Archaeological excavations on the N25 Waterford city bypass. NRA road scheme: Monograph 8.* Dublin, The National Roads Authority, 49 – 51.

Leon, B. C. 2005. Mesolithic and Neolithic activity at Dalkey Island-a reassessment. *Journal of Irish Archaeology,* 14, 1 – 21.

Lisitsyna, O. V., Giesecke, T. & Hicks, S. 2011. Exploring pollen percentage threshold values as an indication for the regional presence of major European trees. *Review of Palaeobotany and Palynology,* 166, 311 – 324.

Liversage, G. D. 1968. Excavations at Dalkey Island, Co. Dublin. *Proceedings of the Royal Irish Academy,* 60C, 53 – 233.

Long, P. 2012. The Vale of Tralee: A summary of the results of archaeological excavations in advance of the N22 Tralee bypass/Tralee to Bealagrellagh road. *Journal of the Kerry Archaeological and Historical Society*, 5 – 44.

Looney, P. L. 2011. *Early Neolithic Pottery in Munster; a review.* Unpublished MPhil thesis, University College Cork.

Louwe Koojimans, L. 2007. The gradual transition to farming in the Lower Rhine Basin. In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* London, Oxford University Press for The British Academy, 287 – 310.

Lynch, A. 1981. *Man and Environment in South-west Ireland*. Oxford, British Archaeological Reports.

Lynch, A. 1988. Poulnabrone: a stone in time. *Archaeology Ireland,* 2, 105 – 107.

Lynch, A. 1994. Poulnabrone portal tomb Burren Co. Clare. *Irish Association for Quaternary Studies, Field Guide no.18,* Dublin, IQUA, 18 – 20.

Lynch, A. 2014. *Poulnabrone: An Early Neolithic Portal Tomb in Ireland. Archaeological Monograph Series: 90,* Dublin, The Stationery Office.

Lynch, A. & Ó Donnabháin, B. 1994. Poulnabrone, Co. Clare. *The Other Clare*, 18, 5 – 7.

Maher Jr, L. J. 1972 Nomograms for computer 0.95 confidence limits of pollen data. *Review of Palaeobotany & Palynology,* 13, 85 – 93.

Mallory, J. & Hartwell, B. 1984. Donegore. *Current Archaeology,* 92, 271 – 274.

Mallory, J. P. 2011. *Excavations on Donegore Hill, Co. Antrim,* Dublin, Wordwell.

McCartan, S. 2004. The Mesolithic of the Isle of Man. In Saville, A. (ed.) *Mesolithic Scotland and its neighbours: The Early Holocene Prehistory of Scotland, its British and Irish Context and some Northern European Perspectives.* Edinburgh, Society of Antiquaries of Scotland, 271 – 283.

McCarthy, M. 1988. *An analysis of the marine molluscan remains from Ferriter's Cove, Dingle, Co. Kerry.* Unpublished MA thesis, University College Cork.

McCarthy, M., Finlay, N. & McClean, O. 1999. The faunal remains. In Woodman, P. C., Anderson, E. & Finlay, N. (eds.) *Excavations at Ferriter's Cove, 1983 – 95: last foragers, first farmers in the Dingle Peninsula.* Bray, Wordwell, 85 – 92.

McClatchie, M., Bogaard, A., Colledge, S., Whitehouse, N. J., Schulting, R. J., Barratt, P. & McLaughlin, T. R. 2014. Neolithic farming in north-western Europe: archaeobotanical evidence from Ireland. *Journal of Archaeological Science,* 51, 206 – 215.

McCormack, F. 2004. Hunting wild pig in the Late Mesolithic. In Roche, H., Grogan, E., Bradley, R., Coles, J. & Raftery, B. (eds.) *From megaliths to metals. Essays in honour of George Eogan.* Oxford, Oxbow Books, 1 – 5.

McCormack, F. 2007. Mammal Bone Studies from Prehistoric Irish sites. In E.M., M. & N.J., W. (eds.) *Environmental Archaeology in Ireland.* Oxford, Oxbow Books, 77 – 101.

Mckinstry, L. 2009. Earlsrath. In Bennett, I. (ed.) *Excavations 2006: summary accounts of archaeological excavations in Ireland.* Dublin, Wordwell, 260.

McKinstry, L. 2010. N9/N10 Kilcullen to Waterford Scheme: Waterford to Knocktopher – Phase 2 Archaeological Resolution, Dunkitt to Sheepstown Co. Kilkenny Final Report A032/000, E3005 Site AR031, Earlsrath, Co. Kilkenny. Unpublished excavation report. Valerie J Keeley Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

McLaughlin, T. R., Whitehouse, N. J., Schulting, R. J., McClatchie, M., Barratt, P. & Bogaard, A. 2016. The Changing Face of Neolithic and Bronze Age Ireland: A Big Data Approach to the Settlement and Burial Records. *Journal of World Prehistory,* 29, 117 – 153.

McNally, A. & Doyle, G. J. 1984. A study of subfossil pine layers in a raised bog complex in the Irish midlands .1. Palaeowoodland extent and dynamics .2. Seral relationships and floristics. *Proceedings of the Royal Irish Academy Section B-Biological Geological and Chemical Science,* 84, 57 – 70.

McQuade, M. 2007a. Final report At Caherabbey Lower N8 Cashel to Mitchelstown Road Improvement Scheme. (E2266). Unpublished excavation report. Margaret Gown & Co Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

McQuade, M. 2007b. N8 Cashel to Mitchelstown Road Improvement Scheme. Final report At Suttonrath. E2128. Unpublished excavation report. Margaret Gowen & Co. Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

McQuade, M. 2008. Gone fishin'. *Archaeology Ireland,* 22(1), 8 – 11.

McQuade, M. & O'Donnell, L. 2006. Late Mesolithic fish traps from the Liffey estuary, Dublin, Ireland. *Antiquity,* 81, 569 – 584.

McSparron, C. 2008. Have you no homes to go to? Neolithic housing. *Archaeology Ireland,* 22, 18 – 21.

Mellars, P. 1976. Fire ecology, animal populations and man: a study of some ecological relationships in prehistory. *Proceedings of the Prehistoric Society,* 42, 15 – 45.

Mercer, P. 2014. *Ritual Aspects of Irish Portal Tombs.* Unpublished PhD Thesis, National University of Ireland, Galway.

Metcalfe, D. J. 2005. Hedera helix L. *Journal of Ecology,* 93, 632 – 648.

Mighall, T., Timpany, S., Blackford, J., Innes, J., O'Brien, C., O'Brien, W. & Harrison, S. 2008. Vegetation change during the Mesolithic and Neolithic on the Mizen Peninsula, Co. Cork, south-west Ireland. *Vegetation History and Archaeobotany,* 17, 617 – 628.

Mighall, T. M. & Lageard, J. G. A. 1999. The prehistoric landscape. In O'Brien, W. (ed.) *Sacred Ground: Megalithic tombs in coastal south-west Ireland.* Galway, Department of Archaeology, National University of Ireland, Galway (Bronze Age Studies 4), 41 – 60.

Mighall, T. M., Lageard, J. G. A., Chambers, F. M., Field, M. H. & Mahi, P. 2004. Mineral deficiency and the presence of Pinus sylvestris on mires during the mid- to late Holocene: palaeoecological data from Cadogan's Bog, Mizen Peninsula, Co. Cork, southwest Ireland. *Holocene,* 14, 95 – 109.

Milner, N. 2010. Subsistence at 4000 – 3700 cal BC: landscapes of change or continuity? In Finlayson, B. & Warren, G. (eds.) *Landscapes in Transition.* Oxford, Oxbow, 46 – 54.

Mitchell, F. 1989. *Man and environment in Valentia Island,* Dublin, F. Mitchell (self published).

Mitchell, F. J. G. 1988. The vegetational history of the Killarney oakwoods, SW Ireland - Evidence from fine spatial-resolution pollen analysis. *Journal of Ecology,* 76, 415 – 436.

Mitchell, F. J. G. 1990a. The History and Vegetation Dynamics of a Yew Wood (Taxus baccata L.) in S.W. Ireland. *New Phytologist,* 115, 573 – 577.

Mitchell, F. J. G. 1990b. The Impact of Grazing and Human Disturbance on the Dynamics of Woodland in S. W. Ireland. *Journal of Vegetation Science,* 1, 245 – 254.

Mitchell, F. J. G. 1993. The biogeographical implications of the distribution and history of the strawberry tree, Arbutus unedo in Ireland. In Costello, M. J. & Kelly, K. S. (eds.) *Biogeography of Ireland: past, present, and future.* Dublin, Irish Biogeographical Society, 35 – 44.

Mitchell, F. J. G. 2006. Where did Ireland's trees come from? *Biology and Environment: Proceedings of the Royal Irish Academy,* 106B, 251 – 259.

Mitchell, F. J. G. 2008. Tree migration into Ireland. *The Irish Naturalists' Journal,* 29, 73 – 75.

Mitchell, F. J. G. 2011. Exploring vegetation in the fourth dimension. *Trends in Ecology & Evolution,* 26, 45 – 52.

Mitchell, F. J. G. & Cooney, T. 2004. Vegetation History in the Killarney Valley. In O'Brien, W. (ed.) *Ross Island: Mining, Metal and Society in Early Ireland.* Galway: Department of Archaeology, National University of Ireland, Galway (Bronze Age Studies 6), 481 – 492.

Mitchell, G. F. 1942. A Composite Pollen Diagram from Co. Meath, Ireland. *The New Phytologist,* 41, 257 – 261.

Mitchell, G. F. 1947. An early kitchen-midden in County Louth. *County Louth Archaeological Journal,* 11, 169 – 174.

Mitchell, G. F. 1949. Further early kitchen-middens in County Louth. *County Louth Archaeological Journal,* 12, 14 – 20.

Mitchell, G. F. 1951. Studies in Irish Quaternary deposits: No.7. *Proceedings of the Royal Irish Academy,* 53B, 111 – 206.

Mitchell, G. F. 1954a. A pollen diagram from Lough Gur, County Limerick (Studies in Irish Quaternary Deposits No:9). *Proceedings of the Royal Irish Academy,* 56C, 481 – 488.

Mitchell, G. F. 1954b. Post-Boreal Pollen-Diagrams from Irish Raised-Bogs (Studies in Irish Quaternary Deposits: No. 11). *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 57, 185 – 251.

Mitchell, G. F. 1956. An early kitchen-midden at Sutton, Co. Dublin. *Journal of the Royal Society of Antiquaries of Ireland,* 86, 1 – 26.

Mitchell, G. F. 1965. Littleton Bog, Tipperary: an Irish agricultural record. *Journal of the Royal Society of Antiquaries of Ireland,* 95, 121 – 132.

Mitchell, G. F. 1971. The Larian culture: a minimal view. *Proceedings of the Prehistoric Society,* 37.

Molleson, T. I. 1985 – 6. New radiocarbon dates for the occupation at Kilgreany cave, Co. Waterford. *Journal of Irish Archaeology,* 3, 1 – 3.

Molloy, B. 2007a. Final Report Caherabbey Upper Co. Tipperary. (E2298) N8 Cashel to Mitchelstown Road Improvement Scheme. Unpublished excavation report. Margaret Gowen & Co. Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

Molloy, B. 2007b. N8 Cashel to Mitchelstown Road Improvement Scheme: Caherabbey Upper, Co. Tipperary. Final Report. E2298. Unpublished excavation report. Margaret Gowen & Co. Ltd. on behalf of South Tipperary County Council and the National Roads Authority.

Molloy, B. 2009. Caherabbey Upper, Co. Tipperary. Possible hut structure and associated features, site 185.1-4 (E2298). *In* McQuade, M., Molloy, B. & Moriarty, C. (eds.) *In the shadow of the Galtees: archaeological excavations along the N8 Cashel to Mitchelstown Road Scheme.* Dublin, The National Roads Authority Scheme Monographs 4, 17 – 21.

Molloy, B. 2010. Final Monitoring Report: BGE Curraleigh West to Middleton Gas Pipeline Counties Tipperary and Cork. Unpublished Excavation Report. Margaret Gowen & Co. Ltd. on behalf of Bord Gáis Éireann.

Molloy, K. 2002. Holocene vegetation and land-use history at Mooghaun, SE Clare, with particular reference to the Bronze Age. In Grogan, E. (ed.) *The North Munster Project: The later prehistoric landscape of south-east Clare. Discover Programme Monograph.* Dublin, The Discovery Programme and the Royal Irish Academy, 255 – 287.

Molloy, K. 2008. Palaeoenvironments. In Doody, M. (ed.) *The Ballyhoura Hills Project.* Bray, Wordwell, 23 – 30.

Molloy, K., Feeser, I. & O'Connell, M. 2014. A pollen profile from Ballinphuill bog: vegetation and land-use history (on CD-ROM: /documents/3/Pollen-analysis-Ballinphuil-bog.pdf). In McKeon, J. & O'Sullivan, J. (eds.) *The quiet landscape: archaeological and palaeoecological investigations on the M6 Galway to Ballinasloe motorway scheme. NRA Scheme Monographs 15.* Dublin, The National Roads Authority.

Molloy, K. & O'Connell, M. 1987. The nature of the vegetational changes at about 5000 B.P. with particular reference to the Elm Decline: Fresh evidence from Connemara, Western Ireland. *New Phytologist,* 107, 203 – 220.

Molloy, K. & O'Connell, M. 1991. Palaeoecological investigations towards the reconstruction of woodland and land-use history at Lough Sheeauns, Connemara, western Ireland. *Review of Palaeobotany and Palynology,* 67, 75 – 113.

Molloy, K. & O'Connell, M. 1995. Palaeoecological investigations towards the reconstruction of environment and land-use changes during prehistory at Céide Fields, western Ireland. *Probleme der Küstenforschung im südlichen Nordseegebiet,* 23, 187 – 225.

Molloy, K. & O'Connell, M. 2011. Prehistoric farming in western Ireland: new evidence from pollen analytical investigations at Caheraphuca, Co. Clare. In Delaney, S., Bayley, D., Lyne, E., McNamara, S., Nunan, J. & Molloy, K. (eds.) *Borderland: Archaeological investigations along the route of the M18 Gort to Crusheen road scheme. NRA Scheme Monographs 9.* Dublin, The National Roads Authority, 109 – 122.

Molloy, K. & O'Connell, M. 2004. Holocene vegetation and land-use dynamics in the karstic environment of Inis Oírr, Aran Islands, western Ireland: pollen analytical evidence evaluated in light of the archaeological record. *Quaternary International,* 113, 41 – 64.

Mongey, L. 1941. The Portal Dolmens of south-eastern Ireland. *Journal of the Waterford Spelaeological Society*, 3 – 22.

Monk, M. 1986. Evidence from macroscopic plant remains for crop husbandry in prehistoric and early historic Ireland: a review. *Journal of Irish Archaeology,* 3, 31 – 36.

Monk, M. 1993. People and environments: in search of farmers. In Shee Twohig, E. & Ronayne, M. (eds.) *Past Perceptions: the prehistoric archaeology of south-west Ireland.* Cork, 35 – 52.

Monk, M. 2000. Seeds and soils of discontent: an environmental archaeological contribution to the nature of the Early Neolithic. In Sheehan, J. & Twohig, E. S. (eds.) *New agendas in Irish Prehistory: papers in commemoration of Liz Anderson.* Dublin, Wordwell, 67 – 88.

Montanari, C. 1996. Recent pollen deposition in alder woods and in other riverine plant communities. *Allionia,* 34, 309 – 323.

Monteith, J. 2009. Kilkeasy. In Bennett, I. (ed.) *Excavations 2006: summary accounts of archaeological excavations in Ireland.* Bray, Wordwell, 269 – 270.

Monteith, J. 2010. N9/N10 Kilcullen to Waterford Scheme: Waterford to Knocktopher-Phase 2. Dunkitt to Knocktopher townlands, Co. Kilkenny. Archaeological Resolution Final Report. E3014. Unpublished excavation report. Valerie J Keeley Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Monteith, J. 2011. N9/N10 Kilcullen to Waterford Scheme: Waterford to Knocktopher – Phase 2. Archaeological Resolution, Dunkitt to Sheepstown Co. Kilkenny. Final Report Scart, Co. Kilkenny. E3001. Unpublished excavation report. Valerie J. Keeley Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Mook, W. G. 1986. Business meeting: recommendations/resolutions adopted by the twelfth International Radiocarbon Conference. *Radiocarbon,* 28, 799.

Mooney, S. & Tinner, W. 2011. The analysis of charcoal in peat and organic sediments. *Mires Peat,* 7**,** 1 – 18.

Moore, M. J. 1999. *Archaeological inventory of County Waterford,* Dublin, Stationery Office.

Moore, P., Evans, A. T. & Chater, M. 1986. Palynological and stratigraphical evidence for hydrological changes in mires associated with human activity. In Behre, K.-E. (ed.) *Anthropogenic Indicators in Pollen Diagrams.* Rotterdam, Balkem, 209 – 220.

Moore, P., Webb, J. & Collinson, M. 1991. *Pollen Analysis,* 2nd Edition. Oxford, Blackwell Scientific.

Mossop, M. & Mossop, E. 2009. Report on the archaeological excavation of Clowanstown 1, Co. Meath. Unpublished Stratigraphic Report. Archaeology Consultancy Services Ltd.

Movius, H. L. 1935. Kilgreany Cave, Co. Waterford. *Journal of the Royal Society of Antiquaries of Ireland,* 65, 254 – 296.

Müller, J. 2010. Ritual Cooperation and Ritual Collectivity: The Social Structure of the Middle and Younger Funnel Beaker North Group (3500 – 2800 BC). In Furholt, M., Lüth, F., Müller, J. & Scarre, C. (eds) *Megaliths and Identities, Early Monuments and Neolithic Societies from the Atlantic to the Baltic. Proceeding of the 3rd European Megalithic Studies Group Meeting 13th - 15th of May 2010 at Kiel University, Germany.* Journal of Neolithic Archaeology, 273 – 284.

Müller, J. 2015. Movement of plants, animals, ideas and people in south-east Europe. In Fowler, C., Harding, J. & Hofmann, D. (eds.) *The Oxford handbook of Neolithic Europe.* Oxford, Oxford University Press, 63 – 80.

Müller, J. & Peterson, R. 2015. Ceramics and society in northern Europe. In Fowler, C., Harding, J. & Hofmann, D. (eds.) *The Oxford handbook of Neolithic Europe.* Oxford, Oxford University Press, 573 – 604.

O'Brien, R. 2014a. N8 Cashel Bypass & N74 Link Road Phase 2 Archaeological Investigations. Monadreela 7, Co. Tipperary. 03E0300. Unpublished excavation report. NRA Archaeology on behalf of South Tipperary County Council and the National Roads Authority.

O'Brien, R. 2014b. N8 Cashel Bypass & N74 Link Road Phase 2 Archaeological Investigations. Monadreela 9, Co. Tipperary. 03E0345. Unpublished excavation report. NRA Archaeology on behalf of South Tipperary County Council and the National Roads Authority.

O'Brien, R. 2014c. N8 Cashel Bypass & N74 Link Road. Phase 2 Archaeological Investigations, Monadreela site 7, 03E0300. Unpublished excavation report, NRA Archaeology on behalf of South Tipperary County Council and the National Roads Authority.

O'Brien, R. 2014d. N8 Cashel Bypass & N74 Link Road. Phase 2 Archaeological Investigations, Monadreela site 9, 03E0345. Unpublished excavation report, NRA

Archaeology on behalf of South Tipperary County Council and the National Roads Authority.

O'Brien, R. 2014e. N8 Cashel Bypass & N74 Link Road. Phase 2 Archaeological Investigations, Monadreela site 11, 03E0346. Unpublished excavation report, NRA Archaeology on behalf of South Tipperary County Council and the National Roads Authority.

O'Brien, W. 1999. *Sacred Ground: Megalithic tombs in coastal south-west Ireland. Bronze Age studies 4,* Galway, Department of Archaeology, National University of Ireland, Galway.

O'Brien, W. 2009. *Local Worlds: Early settlement landscapes and upland farming in south-west Ireland,* Cork, The Collins Press.

O'Carroll, E. 2012. *Quantifying woodland resource usage in the Irish midlands using archaeological and palaeoecological techniques.* Unpublished PhD thesis, Trinity College, Dublin.

O'Carroll, J. 1985. The antiquities of Lisnakill parish. *Decies,* 30, 20 – 24.

O'Connell, A. 2006. N8 Rathcormac/Fermoy Bypass Scheme Archaeological Services Contract Phase 2 – Resolution. Final Report on Archaeological Excavation of Corrin 1 (03E0912). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

O'Connell, A. 2009. N25 Waterford Bypass Archaeological Investigation Contract 1- Final report on the Archaeological excavations of Woodstown 2. 03E0305. Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Waterford County Council and the National Roads Authority.

O'Connell, A. 2013. Corrin 1- settlement: earthwork enclosure (CO053-050/03). *Generations: the archaeology of five national road schemes in County Cork. NRA Scheme Monographs 13.* Dublin, The National Roads Authority, 212 – 215.

O'Connell, M. 1980. The Developmental History of Scragh Bog, Co. Westmeath and the Vegetational History of its Hinterland. *New Phytologist,* 85, 301 – 319.

O'Connell, M. 1986. Reconstruction of local landscape development in the post-Atlantic based on palaeoecological investigations at carrownaglogh prehistoric field system, County Mayo, Ireland. *Review of Palaeobotany and Palynology,* 49, 117 – 176.

O'Connell, M. 1990. Early Land Use in North-East County Mayo: The Palaeoecological Evidence. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 90C, 259 – 279.

O'Connell, M., Huang, C. C. & Eicher, U. 1999. Multidisciplinary investigations, including stable-isotope studies, of thick Late-glacial sediments from Tory Hill, Co. Limerick, western Ireland. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 147, 169 – 208.

O'Connell, M., Mitchell, F. J. G., Readman, P. W., Doherty, T. J. & Murray, D. A. 1987. Palaeoecological investigations towards the reconstruction of the post-glacial environment at Lough Doo, County Mayo, Ireland. *Journal of Quaternary Science,* 2, 149 – 164.

O'Connell, M. & Molloy, K. 1988. Post-glacial landscape evolution in Connemara, western Ireland with particular reference to woodland history. In Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D (eds). *The Cultural Landscape- Past, Present and Future*. Cambridge, University Press, 487 – 514.

O'Connell, M. & Molloy, K. 2001. Farming and Woodland Dynamics in Ireland during the Neolithic. *Proceedings of the Royal Irish Academy, Biology and Environment,* 101B, 99 – 128.

O'Connell, M. & Molloy, K. 2005. Native woodland composition and dynamics: a long-term perspective based on a Holocene pollen profile from Inis Oírr, Aran Islands, western Ireland. In Doyle, C. & Little, D. (eds.) *Ireland's Native Woodlands (on CD Rom).* Dublin, Woodlands of Ireland, 20 – 47.

O'Connell, M., Molloy, K. & McMahon, H. 2001. Reconstructing prehistoric farming activity and human impact at a fine spatial resolution: palaeoecological investigations at Mooghaun, Co. Clare, western Ireland. In Schauer, P. (ed.) *Beiträge zur Siedlungsarchäologie und zum Landschaftswande.* Regensburger, Beiträge zur Prähistorischen Archäologie*,* 161 – 186.

O'Donoghue, J. 2006. Final excavation report of a Neolithic house at Gortore, N8 Rathcormac-Fermoy, County Cork.: Unpublished excavation report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

O'Donoghue, J. 2011. Archaeological excavation report: Mesolithic, Neolithic and Early Bronze Age activity on the banks of the River Funshion at Gortore 1b, County Cork. Prehistoric settlement site. Unpublished excavation report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

O'Donoghue, J. & Johnston, P. 2013. Gortore 1-Early Neolithic house. In Hanley, K. & Hurley, M. F. (eds.) *Generations: the archaeology of five national road schemes in County Cork. NRA Scheme Monographs 13.* Dublin, The National Roads Authority, 46 – 48.

O'Flanagan, M. 1929. *Letters containing information relative to the antiquities of the county of Waterford collected during the progress of the Ordinance Survey in 1841,* Bray, Typescript.

O'Hara, R. 2009. N25 Waterford Bypass Alternative Route. Final report on the archaeological excavation of Butlerstown North 2. (E3440). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Waterford County Council and the National Roads Authority.

O'Hara, R. & Ginn, V. 2011. Butlerstown North 2, Co. Waterford. In Eogan, J. & Shee Twohig, E. (eds.) *Cois tSiúire – nine thousand years of human activity in the lower Suir valley. Archaeological excavations on the N25 Waterford city bypass, vol. 1.* Dublin, NRA road scheme: Monograph 8, 52 – 53.

O'Neill, T. 2006. N8 Rathcormac/Fermoy Bypass Scheme Archaeological Services Contract Phase 2 – Resolution. Final Report on Archaeological Excavation of Curraghprevin 3. (03E1138). Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Cork County Council and the National Roads Authority.

O'Neill, T. 2013. Curraghprevin 3- pit group. *In* Hanley, K. & Hurley, M. F. (eds.) *Generations. The archaeology of five national road schemes in County Cork. NRA Scheme Monographs 13.* Dublin, The National Roads Authority, 49 – 51.

O'Sullivan, A. 1991. *Historical and contemporary effects of fire on the native woodland vegetation of Killarney, S.W. Ireland.* Unpublished PhD thesis, Trinity College, Dublin.

O'Sullivan, A. 2001. *Foragers, Farmers and Fishers in a Coastal Landscape. An intertidal archaeological survey of the Shannon estuary, North Munster Project Discovery Programme Monographs 5* Dublin, The Stationary Office.

O'Sullivan, J. & Stanley, M. 2008. Appendix 1 - radiocarbon dates from excavated archaeological sites described in these proceedings. In O'Sullivan, J. & Stanley, M. (eds.) *Roads, rediscovery and research. Proceedings of a public seminar on archaeological discoveries on national road schemes, August 2007. National Roads Authority Monograph Series No.5.* Dublin, The National Roads Authority, 163 – 171.

Ó Donnabháin, B. 2011. Human Remains. In Cahill, M. & Sikora, M. (eds.) *Breaking ground, finding graves - reports on the excavations of burials by the National Museum of Ireland, 1927 – 2006.* Dublin, Wordwell in association with the National Museum of Ireland, 34 – 47.

Ó Donnabháin, B. & Tesorieri, M. 2014. Bioarchaeology. In Lynch, A. (ed.) *Poulnabrone: An Early Neolithic Portal Tomb in Ireland. Archaeological Monograph Series: 90.* Dublin, The Stationary Office, 61 – 86.

Ó Floinn, R. 1992. A Neolithic cave burial in Limerick. *Archaeology Ireland,* 6(2), 19 – 21.

Ó Floinn, R. 2011. Annagh, Co. Limerick, 92E047. In Cahill, M. & Sikora, M. (eds.) *Breaking ground, finding graves - reports on the excavations of burials by the National Museum of Ireland, 1927 – 2006.* Dublin, Wordwell in association with the National Museum of Ireland, 17 – 33.

Ó Nualláin, S. 1983. Irish portal tombs: topography, siting and distribution. *Journal of the Royal Society of Antiquities Ireland,* 113, 75 – 105.

Ó Ríordáin, S. 1954. Lough Gur excavations: Neolithic and Bronze Age houses on Knockadoon. *Proceedings of the Royal Irish Academy,* 56C, 297 – 459.

O'Connell, M. 1987. Early cereal-type pollen records from Connemara, western Ireland and their possible significance. *Pollen et Spores* 23, 207 – 224.

Overland, A. 2007. *Palaeoecological investigations of lake sediments and peats towards reconstruction of long-term environmental change at Barrees, Beara peninsula, south-west Cork.* Unpublished PhD thesis, National University of Ireland, Galway.

Overland, A. & O'Connell, M. 2008. Fine-spatial palaeoecological investigations towards reconstructing late Holocene environmental change, landscape evolution and farming activity in Barrees, Beara peninsula, southwestern Ireland. *Journal of the North Atlantic* 1, 37 – 73.

Parker, A. G., Goudie, A. S., Anderson, D. E., Robinson, M. A. & Bonsall, C. 2002. A review of the mid-Holocene elm decline in the British Isles. *Progress in Physical Geography,* 26, 1 – 45.

Parnell, J. & Curtis, T. 2012. *Webb's An Irish Flora,* Cork, Cork University Press.

Parsons, R. W., Prentice, I. C. & Saarnisto, M. 1980. Statistical studies on pollen representation in Finnish lake sediments in relation to forest inventory data. *Annales Botanici Fennici,* 17, 379 – 393.

Paus, A. 2010. Vegetation and environment of the Rødalen alpine area, Central Norway, with emphasis on the early Holocene. *Vegetation History & Archaeobotany*, 99(1), 29 – 51.

Pedrosa, S., Uzun, M., Arranz, J.-J., Gutiérrez-Gil, B., San Primitivo, F. & Bayón, Y. 2005. Evidence of three maternal lineages in near eastern sheep supporting multiple domestication events. *Proceedings of the Royal Society B: Biological Sciences,* 272, 2211 – 2217.

Peglar, S. M. & Birks, H. J. B. 1993. The mid-Holocene Ulmus fall at Diss Mere, South-East England — disease and human impact? *Vegetation History and Archaeobotany,* 2, 61 – 68.

Pennington, W. 1979. The Origins of Pollen in Lake Sediments: An enclosed lake compared with one receiving inflow streams. *New Phytologist,* 83, 189 – 213.

Peter Rowley-Conwy 2004. How the West Was Lost: A Reconsideration of Agricultural Origins in Britain, Ireland, and Southern Scandinavia. *Current Anthropology,* 45, 83 – 113.

Pétrequin, A. M., Pétrequin, M. & Cassen, S. 1998. Les longues lames polies des élites. *La Recherche,* 312, 70 – 75.

Piggott, S. 1954. *Neolithic Cultures of the British Isles,* Cambridge, Cambridge University Press.

Pilcher, J. R. 1969. Archaeology, palaeoecology, and 14C dating of the Beaghmore stone circle site. *Ulster Journal of Archaeology,* 32, 73 – 91.

Pilcher, J. R. 1973. Pollen Analysis and Radiocarbon Dating of a Peat on Slieve Gallion, Co. Tyrone, N. Ireland. *The New Phytologist,* 72, 681 – 689.

Pilcher, J. R., Baillie, M. G. L., Brown, D. M., McCormack, F. G., McSweeney, P. B. & McLawrence, A. S. 1995. Dendrochronology of subfossil pine in the north of Ireland. *Journal of Ecology,* 83, 665 – 671.

Pilcher, J. R. & Larmour, R. 1982. Late-Glacial and Post-Glacial Vegetational History of the Meenadoan Nature Reserve, County Tyrone. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 82B, 277 – 295.

Pilcher, J. R. & Smith, A. G. 1979. Palaeoecological Investigations at Ballynagilly, A Neolithic and Bronze Age Settlement in County Tyrone, Northern Ireland. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences,* 286, 345 – 369.

Pilcher, J. R., Smith, A. G., Pearson, G. W. & Crowder, A. 1971. Land Clearance in the Irish Neolithic: New Evidence and Interpretation. *Science,* 172, 560 – 562.

Plunkett, G. 2009a. Land-use patterns and cultural change in the Middle to Late Bronze Age in Ireland: inference from pollen records. *Vegetation History & Archaeobotany,* 18, 273 – 295.

Plunkett, G. 2009b. Socio-political dynamics in later prehistoric Ireland: insights from the pollen record. In Salisbury, R. B. & Thurston, T. (eds.) *Reimagining Regional Analyses: The Archaeology of Spatial and Social Dynamics.* Cambridge, Cambridge Scholars Press, 42 – 66.

Plunkett, G., Carroll, F., Hartwell, B., Whitehouse, N. J. & Reimer, P. J. 2008. Vegetation history at the multi-period prehistoric complex at Ballynahatty, Co. Down, Northern Ireland. *Journal of Archaeological Science,* 35, 181 – 190.

Pollard, J. 2001. The aesthetics of depositional practice. *World Archaeology,* 33(2), 315 – 333.

Powell, T. G. E. 1938. Excavation of a megalithic tomb at Ballynamona Lower, Co. Waterford. *The Journal of the Royal Society of Antiquaries of Ireland,* 68, 260 – 272.

Powell, T. G. E. 1941. Megalithic Tombs in South-Eastern Ireland. *The Journal of the Royal Society of Antiquaries of Ireland,* 11, 9 – 23.

Powell, T. G. E. & Daniel, G. E. 1956. *Barclodiad y Gawres: the excavation of a megalithic chamber tomb in Anglesey. 1952 – 1953,* Liverpool, Liverpool University Press.

Power, C. 1993. Reconstructing Patterns of Health and Dietary Change in Irish Prehistoric Populations. *Ulster Journal of Archaeology,* 56, 9 – 17.

Power, D., Byrne, E., Egan, U., Lane, S. & Sleeman, M. 1992. *Archaeological Inventory of County Cork Volume 1, West Cork,* Dublin, Stationary Office.

Preece, R. C., Coxon, P. & Robinson, J. E. 1986. New Biostratigraphic Evidence of the Post-Glacial Colonization of Ireland and for Mesolithic Forest Disturbance. *Journal of Biogeography,* 13, 487 – 509.

Prentice, I. C. 1983. Pollen Mapping of Regional Vegetation Patterns in South and Central Sweden. *Journal of Biogeography,* 10, 441 – 454.

Prentice, I. C. 1985. Pollen representation, source area, and basin size: Toward a unified theory of pollen analysis. *Quaternary Research,* 23, 76 – 86.

Prentice, I. C., Berglund, B. E. & Olsson, T. 1987. Quantitative forest-composition sensing characteristics of pollen samples from Swedish lakes. *Boreas,* 16, 43 – 54.

Price, T. D. 1983. The European Mesolithic. *American Antiquity,* 48, 761 – 778.

Price, T. D. 1991. The Mesolithic of Northern Europe. *Annual Review of Anthropology,* 20, 211 – 233.

Rackman, O. 1980. *Ancient woodland: its history, vegetation and uses in England,* London, Edward Arnold.

Raemaekers, D. C. M. & Roever, J. P. 2010. The Swifterbant culture (5000 – 3400 BC): matter of fact and matter of interest. In Vanmontfort, B., Louwe Koojimans, L., Amkreutz, L. & Verhart, L. (eds.) *Pots, farmers and foragers.* Leiden, Leiden University Press, 135 – 149.

Ramsey, C. B. 1995. Radiocarbon calibration and analysis of stratigraphy; the OxCal program. *Radiocarbon,* 37, 425 – 430.

Ramsey, C. B., Scott, M. & van der Plicht, H. 2013. Calibration for archaeological and environmental terrestrial samples in the time range 26 – 50 ka cal BP. *Radiocarbon,* 55, 2021 – 2027.

Rasmussen, S. O., Vinther, B. M., Clausen, H. B. & Andersen, K. K. 2007. Early Holocene climate oscillations recorded in three Greenland ice cores. *Quaternary Science Reviews,* 26, 1907 – 1914.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatt, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Staff, R. A., Turney, C. S. M. & van der Plicht, J. 2013. IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0 – 50,000 Years cal BP. *Radiocarbon,* 55, 1869 – 1887.

Renfrew, J. M. 1973. *Palaeoethnobotany: the prehistoric food plants of the Near East and Europe,* London, Methuen.

Richards, M. 2003. Explaining the dietary isotope evidence for the rapid adoption of the Neolithic in Britain. BAR international series 1117. In Parker Pearson, M. (ed.) *Food, culture and identity in the Neolithic and Early Bronze Age.* Oxford, Archaeopress, 31 – 36.

Richardson, D. M. & Rundel, P. W. 1998. Ecology and biogeography of *Pinus*: an introduction. In Richardson, D. M. (ed.) *Ecology and biogeography of Pinus.* Cambridge, Cambridge University Press, 3 – 46.

Richie, G. 1970. Excavations of the chambered cairn at Arhnacreebeag. *Proceedings of the Society for the Antiquaries of Scotland,* 102, 31 – 55.

Risebrobakken, B., Jansen, E., Andersson, C., Mjelde, E. & Hevrøy, K. 2003. A high-resolution study of Holocene paleoclimatic and palaeoceanographic changes in the Nordic Seas. *Palaeoceanography,* 18, 1 – 14.

Robb, J. 2001. Island identities: ritual, travel and the creation of difference in Neolithic Malta. *European Journal of Archaeology,* 4, 175 – 202.

Roberts, J. 1988. *Exploring West Cork,* Skibbereen, Key Books.

Rohling, E. J. & Pälike, H. 2005. Centennial-scale climate cooling with a sudden cold event around 8,200 years ago. *Nature,* 434, 975 – 979.

Rowley-Conwy, P. 1982. Forest grazing and clearance in temperate Europe with special reference to Denmark: an archaeological view. In Bell, M. & Limbrey, S. (eds.) *Archaeological aspects of woodland ecology.* Oxford, British Archaeological Reports, 57 – 74.

Rowley-Conwy, P. 2011. Westward Ho! The Spread of Agriculturalism from Central Europe to the Atlantic. *Current Anthropology,* 52, 431 – 451.

Russell, I. 2006. N25 Waterford Bypass, Archaeological Investigation Contract 1. Report on Archaeological Testing of Alternative Route 2a. Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Waterford County Council and the National Roads Authority.

Russell, I. 2008. Various townlands. In Bennett, I. (ed.) *Excavations 2005: summary accounts of excavations in Ireland, No. 1481.* Dublin, Wordwell, 361.

Russell, I. 2010a. Bawnfune 2. Prehistoric settlement activity. In Bennett, I. (ed.) *Excavations 2007: summary accounts of excavations in Ireland, No. 1801.* Dublin, Wordwell, 510 – 511.

Russell, I. 2010b. N25 Waterford Bypass Archaeological Investigation contract 1- Final report on the Archaeological excavation of Killoteran 9. 03E0406. Unpublished excavation report. Archaeological Consultancy Services Ltd. on behalf of Waterford County Council and the National Roads Authority.

Russell, I. & Harrison, S. 2011. Woodstown 6-Viking Age enclosed settlement and grave. In Eogan, J. & Shee Twohig, E. (eds.) *Cois tSiúire- nine thousand years of human activity in the Lower Suir Valley. Archaeological excavations on the N25 Waterford City Bypass. NRA Scheme Monograph 8.* Dublin, The National Roads Authority, 53 – 72.

Ruttle, E. 2013. Combined N73 Annakisha South and N73 Clogher Cross to Waterdyke Road Realignment Schemes. Shanagh 1, Co. Cork. 12E0086. Unpublished excavation report. TVAS (Ireland) Ltd. on behalf of Cork County Council and the National Roads Authority.

Ryan, M. 1973. The excavation of a Neolithic burial mound at Jerpoint West, Co. Kilkenny. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 73, 107 – 127.

Ryan, M. 1980. An Early Mesolithic site in the Irish midlands. *Antiquity,* 54, 46 – 47.

Ryland, R. R. H. 1824. *The History, topography and antiquities of the county and city of Waterford,* London, John Murray.

Sadovnik, M., Bork, H. R., Nadeau, M. J. & Nelle, O. 2012. Can the period of Dolmens construction be seen in the pollen record? Pollen analytical investigations of Holocene settlement and vegetation history in the Westensee area, Schleswig-Holstein, Germany. In Kluiving, S. J. & Guttmann-Bond, E. B. (eds.) *Landscape Archaeology between art and science- from a multi- to interdisciplinary approach, Landscape and Heritage Series, Proceedings.* Amsterdam, Amsterdam University Press, 197 – 209.

Sadovnik, M., Robin, V., Nadeau, M. J., Bork, H. R. & Nelle, O. 2014. Neolithic human impact on landscapes related to megalithic structures: palaeoecological evidence from the Krahenberg, northern Germany. *Journal of Archaeological Science,* 51, 164 – 173.

Saville, A. 2004. The material culture of Mesolithic Scotland. In Saville, A. (ed.) *Mesolithic Scotland and its neighbours: The Early Holocene Prehistory of Scotland, its British and Irish Context and some Northern European Perspectives.* Edinburgh, The Society of Antiquaries of Scotland, 185 – 220.

Saville, A. 2009. Speculating on the significance of an axe-head and a bead from Luce Sands, Drumfies and Galloway, south-west Scotland. In Finlay, N., McCartan, S., Milner, N. & Wickham-Jones, C. R. (eds.) *From Bann Flakes to Bushmills.* Oxford, Oxbow Books, 50 – 58.

Scarre, C. 2011. *Landscapes of Neolithic Brittany,* Oxford, Oxford University Press.

Schmid, M. M., Zori, D., Erlendsson, E., Batt, C., Damiata, B. N. & Byock, J. 2018. A Bayesian approach to linking archaeological, paleoenvironmental and documentary datasets relating to the settlement of Iceland (Landnam). *Holocene,* 28, 19 – 33.

Schulting, R. 1998. Slighting the sea: stable isotope evidence for the transition to farming in north-western Europe. *Documenta Praehistorica,* XXV, 203 – 218.

Schulting, R. 2012. Skeletal evidence for interpersonal violence: beyond mortuary monuments in southern Britain. In Schulting, R. & Fibiger, L. (eds.) *Sticks, stones and broken bones.* Oxford, Oxford University Press, 223 – 248.

Schulting, R. 2013. On the north-western fringes: earlier Neolithic subsistence in Britain and Ireland as seen through faunal remains and stable isotopes. In Shennan, S., Dobney, K., Colledge, S. & Connolly, J. (eds.) *The Origins and Spread of Stock-keeping in the Near East and Europe.* Walnut Creek, California, Left Coast Press, 313 – 338.

Schulting, R. 2014. The Dating of Poulnabrone. In Lynch, A. (ed.) *Poulnabrone: An Early Neolithic Portal Tomb in Ireland. Archaeological Monograph Series: 90.* Dublin, The Stationery Office, 93 – 113.

Schulting, R. J., McClatchie, M., Sheridan, A., McLaughlin, R., Barratt, P. & Whitehouse, N. J. 2017. Radiocarbon Dating of a Multi-phase Passage Tomb on Baltinglass Hill, Co. Wicklow, Ireland. *Proceedings of the Prehistoric Society,* 83, 305 – 323.

Schulting, R. J., Murphy, E., Jones, C. & Warren, G. 2012. New dates from the north and a proposed chronology for Irish court tombs. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 112C, 1 – 60.

Selby, K. A., O'Brien, C. E., Brown, A. G. & Stuijts, I. 2005. A multi-proxy study of Holocene lake development, lake settlement and vegetation history in central Ireland. *Journal of Quaternary Science,* 20, 147 – 168.

Selby, K. A., O'Brien, C. E., Hatton, J., Brown, A., Ruiz, Z., Stuijts, I., Langdon, P. & Caseldine, C. 2010. Environmental investigations. In Fredengren, C., Kilfeather, A. & Stuijts, I. (eds.) *Lough Kinale: studies of an Irish lake.* Bray, Wordwell, 19 – 89.

Serjeantson, D. 2011. *Review of animal remains from the Neolithic and early Bronze Age of southern Britain,* Swindon, English Heritage.

Shaw, J. & Carter, R. W. G. 1994. Coastal peats from northwest Ireland: implications for late-Holocene relative sea-level change and shoreline evolution. *Boreas,* 23, 74 – 91.

Shee, E. 1967. A portal dolmen at Sheskin, Co. Waterford. *Journal of the Cork Historical and Archaeological Society*, 70 – 71.

Shee Twohig, E. 1990. *Irish megalithic tombs,* London, Shire Publications.

Sheridan, A. 1986. Porcellanite artefacts: a new survey. *Ulster Journal of Archaeology,* 49, 19 – 32.

Sheridan, A. 1995. Irish Neolithic pottery: the story in 1995. In Kinnes, I. & Varndell, G. (eds.) *Unbaked Urns of Rudely Shape, Oxbow Monograph. 55.* Oxford, Oxford University Press, 3 – 21.

Sheridan, A. 2003a. French Connections I. In Armit, I., Murphy, E., Nelis, E. & Simpson, D. (eds.) *Neolithic settlement in Ireland and Western Britain.* Oxford, Oxbow Books, 3 – 17.

Sheridan, A. 2003b. Ireland's earliest 'passage' tombs: a French connection? In Burenhult, G. & Westergaard, S. (eds.) *Stones and Bones: Formal Disposal of the Dead in Atlantic Europe during the Mesolithic-Neolithic Interface 6000 – 3000 BC.* Oxford, British Archaeological Reports (International Series 1201), Archaeopress, 9 – 25.

Sheridan, A. 2004. Neolithic connections along and across the Irish Sea. In Cummings, V. & Fowler, C. (eds.) *The Neolithic of the Irish Sea: Materiality and traditions of practice.* Oxford, Oxbow, 9 – 21.

Sheridan, A. 2007. From Picardie to Pickering and Pencraig Hill? New information on the 'Carinated Bowl Neolithic' in northern Britain. . In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* Oxford, Oxford University Press for The British Academy, 441 – 492.

Sheridan, A. 2010. The Neolithization of Britain and Ireland: the 'big picture'. In Finlayson, B. & Warren, G. (eds.) *Landscapes in transition.* Oxford, Oxbow, 89 – 105.

Sherratt, A. 1995. Instruments of Conversion? The role of megaliths in the Mesolithic/Neolithic Transition in northwest Europe. *Oxford Journal of Archaeology,* 14, 245 – 260.

Simmons, I. G. & Innes, J. B. 1996. Disturbance Phases in the Mid-Holocene Vegetation at North Gill, North York Moors: Form and Process. *Journal of Archaeological Science,* 23, 183 – 191.

Singh, G. & Smith, A. G. 1973. Post-Glacial Vegetational History and Relative Land- and Sea-Level Changes in Lecale, Co. Down. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 73, 1 – 51.

Sjögren, K.-G. 2010. Megaliths, Landscapes and Identities: the case of Falbygden, Sweden. In Furholt, M., Lüth, F., Müller, J. & Scarre, C. (eds) *Megaliths and Identities, Early Monuments and Neolithic Societies from the Atlantic to the Baltic. Proceeding of the 3rd European Megalithic Studies Group Meeting 13th - 15th of May 2010 at Kiel University, Germany.* Journal of Neolithic Archaeology, 155 – 166.

Sjögren, P., Solem, T., Stenvik, L. F., Tretvik, A. M., Daverdin, M., Speed, J. D. M. & Austrheim, G. 2014. Quantification of past plant abundances based on the R-value model: Exemplified by an impact assessment of pre-historic iron production and summer farming in Budalen, central Norway. *Holocene,* 24, 454 – 465.

Smith, A. G. 1957. Pollen Analytical Investigations of the Mire at Fallahogy Td., Co. Derry. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 59, 329 – 343.

Smith, A. G. 1970. The influence of Mesolithic and Neolithic man on British vegetation. In Walker, D. & West, R. G. (eds.) *Studies in the vegetational history of the British Isles* Cambridge, Cambridge University Press, 81 – 96.

Smith, A. G. 1975. Neolithic and Bronze Age landscape changes in Northern Ireland. In Evans, J. G., Limbrey, S. & Cleeve, H. (eds.) *The effect of Man on the landscape: The Highland zone.* London: Council for British Archaeology, 64 – 74.

Smith, A. G. & Goddard, I. C. 1991. A 12500 Year Record of Vegetational History at Sluggan Bog, Co. Antrim, N. Ireland (Incorporating a Pollen Zone Scheme for the Non-Specialist). *The New Phytologist,* 118, 167 – 187.

Smith, A. G., Pilcher, J. R. & Pearson, G. W. 1971. New radiocarbon dates from Ireland. *Antiquity,* 45, 97 – 102.

Smith, A. G. & Willis, E. H. 1961. Radiocarbon Dating of the Fallahogy Landnam Phase. *Ulster Journal of Archaeology,* 24/25, 16 – 24.

Smith, B. D. 2011. General patterns of niche construction and the management of 'wild' plant and animal resources by small-scale pre-industrial societies. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 366, 836 – 848.

Smith, C. 1992. *Late Stone Age Hunters of the British Isles,* London and New York, Routledge.

Smyth, J. 2006. The Role of the House in Early Neolithic Ireland. *European Journal of Archaeology,* 9, 229 – 257.

Smyth, J. 2007. Neolithic Settlement in Ireland: New Theories and Approaches. Unpublished PhD thesis, University College Dublin.

Smyth, J. 2011. The house and group identity in the Irish Neolithic. *Proceedings of the Royal Irish Academy. Section C: Archaeology, Celtic Studies, History, Linguistics, Literature,* 111C, 1 – 31.

Smyth, J. 2012. Breaking ground: An overview of pits and pit-digging in Neolithic Ireland. In Anderson-Whymark, H. & Thomas, J. (eds.) *Regional perspectives on Neolithic pit deposition: Beyond the mundane.* Oxford: Oxbow, 13 – 29.

Smyth, J. 2013. Tides of Change? The House through the Irish Neolithic. In Hofmann, D. & Smyth, J. (eds.) *Tracking the Neolithic House in Europe: Sedentism, Architecture and Practice.* New York, Springer New York, 301 – 327.

Smyth, J. 2014. *Settlement in the Irish Neolithic. New discoveries at the edge of Europe. Prehistoric Society Research Paper 6 in association with the Heritage Council, Ireland,* Oxford, Oxbow.

Smyth, J. & Evershed, R. 2015a. Milking the megafauna; using organic residue analysis to understand early farming practices. *Environmental Archaeology,* 21, 214 – 229.

Smyth, J. & Evershed, R. 2015b. The molecules of meals: new insights into Neolithic foodways. *Proceedings of the Royal Irish Academy,* 115, 1 – 20.

Smyth, J. & O'Flaherty, R. 2015. From the ground up: engineering Irish Early Neolithic Houses. *Archaeology Ireland,* 29, 12 – 15.

Stace, C. 1997. *New Flora of the British Isles* 2nd Edition, Cambridge, Cambridge University Press.

Stefanini, B. 2008. *A comparison of climate and vegetation dynamics in central Ireland and NW Spain since the mid-Holocene.* Unpublished PhD thesis, Trinity College Dublin.

Stefanini, B. 2009. Kilkenny Court House pollen and microfossil assessment. Unpublished report on behalf of Arch-Tech Ltd, Dublin.

Stefanini, B. & Mitchell, F. J. G. 2011. *IPOL, the Irish Pollen Site Database* [Online]. Available: www.ipol.ie [Accessed 14/04/2016].

Steier, P. & Rom, W. 2000. The use of Bayesian statistics for 14C dates of chronologically ordered samples: a critical analysis. *Radiocarbon,* 42, 183 – 198.

Stockmarr, J. 1971. Tablets with spores used in absolute pollen analysis. *Pollen et Spores,* 13, 615 – 621.

Stolze, S. 2012a. High-resolution palaeoecological data from the Carrowkeel area, western Ireland: Landscape change and human settlement dynamics during the fourth millennium BC. *Quaternary International,* 279 – 280, 470.

Stolze, S. 2012b. *Human impact and environmental change during the Neolithic in the Carrowkeel-Keshcorran area, County Sligo, Ireland.* Unpublished PhD thesis, Christian-Albrechts University, Kiel.

Stolze, S., Dörfler, W., Monecke, T. & Nelle, O. 2012. Evidence for climatic variability and its impact on human development during the Neolithic from Loughmeenaghan, County Sligo, Ireland. *Journal of Quaternary Science,* 27, 393 – 403.

Stolze, S., Dörfler, W. & Nelle, O. 2013a. A High-Resolution Palaeoecological Reconstruction of Landscape Change and Human Development during the Fourth Millennium BC in the Carrowkeel / Keshcorran Area, County Sligo. In Timoney, M. (ed.) *Dedicated to Sligo. Thirty-four essays on Sligo's past.* Sligo: Publishing Sligo's Past, 29 – 36.

Stolze, S., Muscheler, R., Dörfler, W. & Nelle, O. 2013b. Solar influence on climate variability and human development during the Neolithic: evidence from a high-resolution multi-proxy record from Templevanny Lough, County Sligo, Ireland. *Quaternary Science Reviews,* 67, 138 – 159.

Stuiver, M. & Kra, R. S. 1986. Editorial comment. *Radiocarbon,* 28(2B), ii.

Stuiver, M. & Polach, H. A. 1977. Reporting of 14C data. *Radiocarbon,* 19, 355 – 363.

Stuiver, M. & Reimer, P. J. 1986. A computer program for radiocarbon age calculation. *Radiocarbon,* 28(2B), 1022 – 1030.

Stuiver, M. & Reimer, P. J. 1993. Extended 14C database and revised CALIB 3.0 14C age calibration program. *Radiocarbon,* 35, 215 – 230.

Sugita, S. 1994. Pollen Representation of Vegetation in Quaternary Sediments: Theory and Method in Patchy Vegetation. *Journal of Ecology,* 82, 881 – 897.

Sugita, S., Gaillard, M.-J. & Broström, A. 1999. Landscape openness and pollen records: a simulation approach. *Holocene,* 9, 409 – 421.

Tallantire, P. A. 1992. The alder [Alnus glutinosa (L.) Gaertn.] problem in the British Isles: a third approach to its palaeohistory. *New Phytologist,* 122, 717 – 731.

Tallantire, P. A. 2002. The early-Holocene spread of hazel (Corylus avellana L.) in Europe north and west of the Alps: an ecological hypothesis. *Holocene,* 12, 81 – 96.

Taylor, K. & Ruttle, E. 2013. Limerick Southern Ring Road, Phase II. E2091, Coonagh West Site 4, Co. Limerick Final Archaeological Excavation Report. Unpublished excavation report. TVAS (Ireland) Ltd. on behalf of Limerick County Council and the National Roads Authority.

Taylor, K. J., Potito, A. P., Beilman, D. W., Ghilardi, B. & O'Connell, M. 2013. Palaeolimnological impacts of early prehistoric farming at Lough Dargan, County Sligo, Ireland. *Journal of Archaeological Science,* 40, 3212 – 3221.

Thomas, E. R., Wolff, E. W., Mulvaney, R., Steffensen, J. P., Johnsen, S. J., Arrowsmith, C., White, J. W. C., Vaughn, B. & Popp, T. 2007. The 8.2ka event from Greenland ice cores. *Quaternary Science Reviews,* 26, 70 – 81.

Thomas, J. 1988. Neolithic Explanations Revisited: The Mesolithic-Neolithic Transition in Britain and South Scandinavia. *Proceedings of the Prehistoric Society,* 54, 59 – 66.

Thomas, J. 2004. Current debates on the Mesolithic-Neolithic transition in Britain and Ireland. *Documenta Praehistorica,* 31, 113 – 130.

Thomas, J. 2012. Introduction: beyond the mundane. In Anderson-Whymark, H. & Thomas, J. (eds.) *Regional perspectives on Neolithic pit deposition.* Oxford, Oxbow Books, 1 – 12.

Thomas, J. 2013. *The birth of Neolithic Britain: an interpretive account,* Oxford, Oxford University Press.

Thompson, R. & Edwards, K. J. 1982. A Holocene palaeomagnetic record and a geomagnetic master curve from Ireland. *Boreas,* 11, 335 – 349.

Thorpe, N. 2015. The Atlantic Mesolithic-Neolithic transition. In Fowler, C., Harding, J. & Hofmann, D. (eds.) *The Oxford handbook of Neolithic Europe.* Oxford: Oxford University Press, 215 – 229.

Tierney, J. 2005. N25 Road Realignment Scheme, Kilmacthomas, C. Waterford. Final archaeological testing report on archaeology found in Ahanaglogh and Graigueshoneen townlands, Kilmacthomas, Co. Waterford. (98E0575). Unpublished excavation report. Eachtra Archaeological Projects on behalf of Waterford County Council and the National Roads Authority.

Tierney, J. & Frazer, W. 2008. Early Neolithic settlement: Area 1, Graigueshoneen Td. Licence No. 98E0575. In Johnston, P., Kiely, J. & Tierney, J. (eds.) *Near the bend in the river; the archaeology of the N25 Kilmacthomas realignment. NRA Scheme Monographs 3.* Dublin: The National Roads Authority, 19 – 21.

Tierney, J. & Johnston, P. 2011. Archaeological Excavation Report. Prehistoric activity at Ballynamona 1 Co. Cork. (E2428). Unpublished Excavation Report. Eachtra Archaeological Projects on behalf of Cork County Council and the National Roads Authority.

Tierney, M. 2003. N25 Road Realignment Scheme, Kilmacthomas, Co. Waterford. Final Report on archaeological testing report on structures and iron-working debris found at Cooltubrid East, Kilmacthomas, Co. Waterford (00E0059). Unpublished excavation report. Eachtra Archaeological Projects on behalf of Waterford County Council and the National Roads Authority.

Tierney, M. 2008. Late Bronze Age settlement: Area 25, Cooltubrid East td. Licence No. 00E0059. In Johnston, P., Kiely, J. & Tierney, J. (eds.) *Near the bend in the river: the archaeology of the N25 Kilmacthomas realignment. NRA Scheme Monographs 3.* Dublin, The National Roads Authority, 47 – 54.

Timpany, S. 2009. Appendix 9: Palaeoenvironmental Analyses Report, Site 34, Newrath Townland, Co. Kilkenny. N25 Waterford Bypass, Contract 3. Final Report on archaeological Investigations at Site 34 in the townland of Newrath, Co Kilkenny. Unpublished excavation report, Headland Archaeology on behalf of Kilkenny County Council and the National Roads Authority.

Tinner, W., Nielsen, E. H. & Lotter, A. F. 2007. Mesolithic agriculture in Switzerland? A critical review of the evidence. *Quaternary Science Reviews,* 26, 1416 – 1431.

Tipping, R., Ashmore, P., Davies, A. L., Haggart, B. A., Moir, A., Newton, A., Sands, R., Skinner, T. & Tisdall, E. 2008. Prehistoric Pinus woodland dynamics in an upland landscape in northern Scotland: the roles of climate change and human impact. *Vegetation History and Archaeobotany,* 17, 251 – 267.

Tratman, E. K., Jackson, J. W. & Fawcett, E. 1928. Reports on excavations in Ireland. *Proceedings of the University of Bristol Spelaeological Society,* 3, 109 – 153.

Tresset, A. 2000. Early husbandry in Atlantic areas. Animal introductions, diffusions of techniques and native acculturation at the north-west fringe of Europe. In Henderson, J. (ed.) *The Prehistory and Early History of Atlantic Europe. British Archaeological Reports, International Series 861.* Oxford: Archaeopress, 17 – 32.

Tresset, A. 2003. French connections II: of cows and men. In Armit, I., Murphy, E., Nelis, E. & Simpson, D. (eds.) *Neolithic settlement in Ireland and western Britain.* Oxford: Oxbow Books, 18 – 30.

Tresset, A. & Vigne, J. D. 2007. Substitution of species, techniques and symbols at the Mesolithic-Neolithic transition in western Europe. In Whittle, A. & Cummings, V. (eds.) *Going over: the Mesolithic-Neolithic transition in north-west Europe.* London, Oxford University Press for The British Academy, 189 – 210.

Troels-Smith, J. 1953. Ertebøllekultur-Bondekultur. Resultaten af de sideste 10 aars undersøgelser i Aamosen, Vestsjælland. *Aarbøger for Nordisk Oldkyndighed og Historie,* 5 – 62.

Troels-Smith, J. 1955. Characterization of unconsolidated sediments *Geological survey of Denmark. Series iv,* 3, 38 – 73.

Troels-Smith, J. 1960. Ivy, mistletoe and elm climate indicators - fodder plants : a contribution to the interpretation of the pollen zone border VII-VIII. *Danmarks Geologiske Undersøgelse II,* Series IV, 1 – 32.

Turner, J. 1970. Surface sample analyses from Ayrshire, Scotland. *Pollen et Spores,* 6, 583 – 592.

Tweddle, J. C., Edwards, K. J. & Fieller, N. R. J. 2005. Multivariate statistical and other approaches for the separation of cereal from wild Poaceae pollen using a large Holocene dataset. *Vegetation History & Archaeobotany,* 14, 15 – 30.

Van Wijngarden-Bakker, L. H. 1989. Faunal remains and the Irish Mesolithic. In Bonsall, C. (ed.) *The Mesolithic in Europe. Proceedings of the Third International Symposium, Edinburgh 1985.* Edinburgh: John Donald Publishers Ltd, 125 – 133.

Vanmontfort, B. 2007. Bridging the gap. The Mesolithic-Neolithic transition in a frontier zone. *Documenta Praehistorica,* 34, 105 – 118.

Vokes, E. 1966. *Late-glacial and Post-glacial vegetation of Killarney, Co. Kerry.* Unpublished M.Sc. thesis, Trinity College, Dublin.

Waddell, J. 2010. *The prehistoric archaeology of Ireland,* Bray, Wordwell.

Waller, M. P., Long, A. J. & Schofield, J. E. 2006. Interpretation of radiocarbon dates from the upper surface of late-Holocene peat layers in coastal lowlands. *Holocene,* 16, 51 – 61.

Walsh, P. 2015. *KE047-052----, Killaclohane* [Online]. archaeology.ie. Available: http://webgis.archaeology.ie/historicenvironment/ [Accessed 15/02/18].

Ward, G. K. & Wilson, S. R. 1978. Procedures for Comparing and Combining Radiocarbon Age Determinations: A Critique. *Archaeometry,* 20, 19 – 31.

Warren, G., Davis, S., McClatchie, M. & Sands, R. 2014. The potential role of humans in structuring the wooded landscapes of Mesolithic Ireland: a review of data and discussion of approaches. *Vegetation History & Archaeobotany,* 23, 629 – 646.

Waterbolk, H. T. 1971. Working with Radiocarbon Dates. *Proceedings of the Prehistoric Society,* 37, 15 – 33.

Watts, W. A. 1963. Late-glacial pollen zones in western Ireland. *Irish Geography,* 4, 367 – 376.

Watts, W. A. 1964. Interglacial deposits at Baggotstown, near Bruff, Co. Limerick. *Proceedings of the Royal Irish Academy,* 63B, 167 – 189.

Watts, W. A. 1966. Interglacial deposits in Kildromin townland, near Herbertstown, Co. Limerick. *Proceedings of the Royal Irish Academy,* 65B, 339 – 348.

Watts, W. A. 1984a. The Holocene vegetation of the Burren, western Ireland. In Haworth, E. Y. (ed.) *Lake sediments and environmental history.* Leicester: Leicester University Press, 360 – 376.

Watts, W. A. 1984b. The Holocene vegetation of the Burren, western Ireland. In Haworth, E. Y., Lund, J. W. G. & Tutin, W. (eds.) *Lake sediments and environmental history: studies in palaeolimnology and palaeoecology in honour of Winifred Tutin.* Leicester: Leicester University Press, 359 – 376.

Watts, W. A. & Ross, R. 1959. Interglacial Deposits at Kilbeg and Newtown, Co. Waterford. *Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science,* 60, 79 – 134.

Welinder, S. 1977. *The Mesolithic Stone Age of Eastern Middle Sweden,* Scockholm, Antikvarskt Arkiv.

Welten, M. 1952. Pollenanalytische Stichproben über die subrezente Vegetationsentwicklung im Bergland von Kerry (Ireland). In Lüdi, W. (ed.) *Die Pflanzenwelt Irlands.* Bern: Hans Huber, 85 – 99.

Whitefield, A. 2017. Neolithic 'Celtic' Fields? A Reinterpretation of the Chronological Evidence from Céide Fields in North-western Ireland. *European Journal of Archaeology,* 20, 257 – 279.

Whitehouse, N. J., Schulting, R. J., McClatchie, M., Barratt, P., McLaughlin, T. R., Bogaard, A., Colledge, S., Marchant, R., Gaffrey, J. & Bunting, M. J. 2014. Neolithic agriculture on the European western frontier: the boom and bust of early farming in Ireland. *Journal of Archaeological Science,* 51, 181 – 205.

Whittle, A. 1996. *Europe in the Neolithic,* Cambridge, Cambridge University Press.

Whittle, A. 1997. Moving on and moving around: Neolithic settlement mobility. In Topping, P. (ed.) *Neolithic landscapes.* Oxford: Oxbow, 81 – 90.

Whittle, A. 2000. 'Very like a whale': menhirs, motifs and myths in the Mesolithic-Neolithic transition of northwest Europe. *Cambridge Archaeological Journal,* 10, 243 – 259.

Whittle, A. 2004. Stones that float to the sky: portal dolmens and their landscape of memory and myth. In Cummings, V. & Fowler, C. (eds.) *The Neolithic of the Irish Sea: Materiality and Traditions of practice.* Oxford: Oxbow Books, 81 – 90.

Whittle, A. 2007. Going over: people and their times. *Proceedings of the British Academy,* 144, 617 – 628.

Whittle, A., Healy, F. & Bayliss, A. 2011. *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland,* Oxford, Oxbow Books.

Wickham-Jones, C. R. & Woodman, P. C. 1998. Studies on the early settlement of Scotland and Ireland. *Quaternary International,* 49/50, 13 – 20.

Wiersma, A. P. & Renssen, H. 2006. Model–data comparison for the 8.2kaBP event: confirmation of a forcing mechanism by catastrophic drainage of Laurentide Lakes. *Quaternary Science Reviews,* 25, 63 – 88.

Wilkins, B. 2006. N25 Waterford Bypass, Contract 3. Final Report on Archaeological Investigations at Site 35 in the townland of Newrath, Co Kilkenny. 04E0319. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wilkins, B., Timpany, S. & Drum, M. 2009. N25 Waterford Bypass, Contract 3. Final Report on archaeological Investigations at Site 34 in the townland of Newrath, Co Kilkenny. 04E0319. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wobst, M. 1977. Stylistic behaviour and information exchange. In Cleland, C. E. (ed.) *For the Director: Research essays in Honour of James B. Griffin,* Ann Arbor, Museum of Anthropology, University of Michigan, 317 – 342.

Woodman, P., McCarthy, M. & Monaghan, N. 1997. The Irish quaternary fauna project. *Quaternary Science Reviews,* 16, 129 – 159.

Woodman, P. C. 1978. *The Mesolithic in Ireland: Hunter-Gatherers in an Insular Environment,* Oxford, British Archaeological Reports 58.

Woodman, P. C. 1981. The postglacial colonisation of Ireland: the human factors. In Ó Corráin, D. (ed.) *Irish Antiquity.* Cork, Tower Books, 93 – 110.

Woodman, P. C. 1985. *Excavations at Mount Sandel, 1973 – 77, Archaeological Monograph 2,* Belfast, Northern Ireland, Her Majesty's Stationary Office.

Woodman, P. C. 1986. Problems in the colonisation of Ireland. *Ulster Journal of Archaeology,* 49, 7 – 18.

Woodman, P. C. 1992. Filling in the spaces in Irish prehistory. *Antiquity,* 66, 295 – 314.

Woodman, P. C. 1993. Towards a definition of Irish early Neolithic lithic assemblages In Ashton, N. & David, A. (eds.) *Stories in Stone*, Oxford, Lithic Studies Society Occasional Paper No 4/Oxbow, 212 – 218.

Woodman, P. C. 1997. Killuragh cave. In Bennett, I. (ed.) *Excavations 1996 : summary accounts of archaeological excavations in Ireland.* Bray, Wordwell, 67 – 68.

Woodman, P. C. 1998. Pushing the boat out for an Irish Palaeolithic. In Ashton, N., Healy, F. & Pettitt, P. (eds.) *Stone Age Archaeology. Essays in Honour of John Wymer.* Oxford: Lithic Studies Society Occasional Paper 6/Oxbow Books, 146 – 157.

Woodman, P. C. 2015. *Ireland's first settlers, Time and the Mesolithic,* Oxford & Philadelphia, Oxbow Books.

Woodman, P. C. 2016. The Introduction of Cattle into Prehistoric Ireland: Fresh Perspectives. In O'Connell, M., Kelly, F. & McAdam, J. (eds.) *Cattle in Ancient and Modern Ireland: Farming Practices, Environment and Economy.* Newcastle upon Tyne, Cambridge Scholars Publishing, 12 – 26.

Woodman, P. C. & Anderson, E. 1990. The Irish Later Mesolithic: a partial picture. In Vermeersch, M. & Van Peer, P. (eds.) *Contributions to the Mesolithic in Europe.* Leuven, Leuven University Press, 377 – 387.

Woodman, P. C., Anderson, E. & Finlay, N. 1999. *Excavations at Ferriter's Cove, 1983 – 95: last foragers, first farmers in the Dingle Peninsula,* Bray, Wordwell.

Woodman, P. C., Finlay, N. & Anderson, E. 2006. *The Archaeology of a Collection: The Keiller-Knowles Collection of the National Museum of Ireland. National Museum of Ireland Monograph Series 2,* Bray, Wordwell.

Woodman, P. C. & McCarthy, M. 2003. Contemplating some awful(ly interesting) vistas: importing cattle and red deer into prehistoric Ireland. In Armit, I., Murphy, E., Nelis, E. & Simpson, D. (eds.) *Neolithic settlement in Ireland and western Britain.* Oxford, Oxbow Books, 31 – 39.

Wren, J. 2006a. N25 Waterford Bypass, Contract 3. Final Report on archaeological investigations at Site 4 in the townland of Mullinabro, Co. Kilkenny. 04E332. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wren, J. 2006b. N25 Waterford Bypass, Contract 3. Final Report on archaeological Investigations at Site 34 in the townland of Newrath, Co Kilkenny. 04E0289. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wren, J. 2006c. N25 Waterford Bypass, Contract 3. Final report on excavations at sites 36 & 37, in the townland of Newrath, Co. Kilkenny. 04E288. Unpublished excavation report. Headland Archaeology Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wren, J. 2010. N9/N10 Kilcullen to Waterford Scheme: Waterford to Knocktopher – Phase 2 Archaeological Resolution. Dunkitt to Sheepstown townlands, Co. Kilkenny. Sites 10-12, Ballykeoghan Townland, Co Kilkenny. (E2501). Unpublished excavation report. Valerie J. Keeley Ltd. on behalf of Kilkenny County Council and the National Roads Authority.

Wren, J. & Price, J. 2011. Newrath 37-Neolithic building and Early Bronze Age cemetery. In Grogan, E. & Shee Twohig, E. (eds.) *Cois tSiúire-nine thousand years of human activity in the Lower Suir Valley. Archaeological excavations on the N25 Waterford City Bypass. NRA Scheme Monographs 8.* Dublin, The National Roads Authority, 135 – 146.

Wymer, J. J. 1962. Excavations at the Maglemosian sites at Thatcham, Berkshire, England. *Proceedings of the Prehistoric Society,* 28, 329 – 361.

Zvelebil, M. 1994. Plant use in the Mesolithic and its role in the transition to farming. *Proceedings of the Prehistoric Society,* 79, 35 – 74.

Zvelebil, M. 2000. The social context of the agricultural transition in Europe. In Renfrew, C. & Boyle, K. (eds.) *Archaeogenetics: DNA and the population.* Cambridge, McDonald Institute for Archaeological Research, 57 – 79.

Zvelebil, M. & Rowley-Conwy, P. 1986. Foragers and farmers in Atlantic Europe. In Zvelebil, M. (ed.) *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming.* Cambridge, Cambridge University Press, 67 – 96.

Zvelebil, M. & Rowley-Conwy, P. 1984. Transition to farming in Northern Europe: A hunter-gatherer perspective. *Norwegian Archaeological Review,* 17, 104 – 128.